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The European Server for Ionospheric specification and forecasting: Final results from DIAS project

A. Belehaki (1), Lj. Cander (2), B. Zolesi (3), J. Bremer (4), C. Juren (5), I. Stanislawska (6), D. Dialetis (7) and M. Hatzopoulos (7)

(1) National Observatory of Athens, Greece
(2) Rutherford Appleton Laboratory, UK
(3) National Institute of Geophysics and Volcanology, Italy
(4) Leibniz Institute of Atmospheric Physics, Germany
(5) Swedish Institute of Space Physics
(6) Space Research Center, Polish Academy of Sciences
(7) University of Athens, Greece

Abstract

The main objective of DIAS (European **Di**gital Upper **A**tmosphere **S**erver) project is to develop a pan-European digital data collection on the state of ionospheric part of the upper atmosphere, based on real-time information and historical data collections provided by most operating ionospheric stations in Europe (Athens, Rome, Ebre, Juliusruh, Chilton, Pruhonice, Lycksele and Warsaw). Based on the raw data collection, DIAS system develops and distributes several products required by various groups of users for nowcasting and forecasting purposes. The DIAS server (http://www.iono.noa.gr/DIAS) operates since May 2005 and the basic products that are delivered are real-time and historical ionograms from all DIAS ionospheric stations, frequency plots and maps of the ionosphere over Europe based on the foF2, M(3000)F2, MUF and electron density parameters, as well as long term and short term forecasting up to 24 hour ahead. The paper reports on the operation of this new system, giving information on the models applied for the specification and forecasting of the ionosphere over the European region, and on the users' experience.

Introduction

The demand for reliable products that characterize the state of the ionosphere with high accuracy is nowadays very pressing, not only due to the specific needs of the European space industry (EGNOS and GALILEO) but also due to many applications operated by several market serctors. Radio frequency communications and satellite navigation and positioning systems can be adversely affected by disturbances caused directly by solar events and indirectly by effects in the near Earth environment. In particular HF sky-wave users, and also satellite communications (SATCOMS) operators can be affected by solar-induced, ionospheric disturbances. Depending upon the severity of the disturbances, the effects can cause significant degradation of the communications circuits and in the most extreme cases total outage of the systems causing potentially costly commercial and economic consequences. For military and civil defence communication applications for which HF is used, the ability to respond rapidly to dynamically changing external

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environmental effects is a key factor in enabling support for security, protection and control.
DIAS system [Ref. 1] has as primary objective to cover the needs of the market for reliable information on the current conditions of the ionosphere over Europe and for accurate forecasting information in long term and short term time scales. Europe has the advantage, in contrast to other world areas, to have in operation many ionospheric stations with a satisfactory geographic distribution. Nevertheless, even until recently, these stations operated independently, making the full exploitation of the ionospheric observations a very difficult task. DIAS managed for the first time to create a network among most of the European ionospheric stations, which is designed to serve radio propagation systems.
The paper reports on the operation of this new system, giving information on the models applied for the specification and forecasting of the ionosphere over the European region, and on the users' experience.

Tools for ionospheric specification and prediction

The development of the DIAS system has two fundamental components, the building of the DIAS server and the design and development of the added-value products and services.

The DIAS server development was based on a three layers' architecture. Layer 1 is the digital ionosondes data layer and consists of the soundings collected at all the participating stations in the DIAS network. To support DIAS, an information collector is installed at each station which uploads the ionograms and associated data to the central DIAS server. Layer 2 is the central DIAS server. In this layer all the ionospheric data is converted into a common format and stored in a database. Within layer 2 functionality exists which generates the numerous added-value products and services. These products are then made available as services via the World Wide Web (WWW). Layer 3 is the user layer and is the interface to the services and information products. The intention is that as well as provision of http, hmtl and xml pages, ionospheric alerts will be sent to users via email or other text means.

The design and development of the added-value products was based on a comprehensive set of ionospheric models. These are used in conjunction with the ionospheric data sets derived from the contributing ionosondes.
The main models used in generating the products are:
1. The Simplified Ionospheric Regional Model (SIRM) used to provide long term forecasting maps of the foF2 & M(3000)F2 parameters. A full description of the model is given in Ref. [2].
2. The Simplified Ionospheric Regional Model Updated in real-time (SIRMUP) which uses real-time ionospheric sounder parameters (foF2 & M(3000)F2) to provide immediately updated nowcast maps. The method is described in Ref [3].
3. Ne3D which is a three dimensional instantaneous model of the ionospheric electron density used to calculate the distribution of the electron density with height over Europe and the method is described in Ref [4].

4. The Geomagnetically Correlated Auto-regression Model (GCAM) which provides nowcasts, short-term forecasts of foF2 for up to 24 hours ahead. The method is described in Ref [5].
5. The Time Series forecasting models for Absolute and Relative foF2 (TSAR-foF2) which provides forecasts of the foF2 parameter for up to 24 hours ahead, Ref [6].
6. Extensions to the SIRM and SIRMUP models to produce grided sets of the basic Maximum Usable Frequencies (MUFs), using the methods described in Ref [7].
7. The ionospheric Activity Index (AI) which is used to give a measure of the disturbed behaviour of the current ionospheric state, using the methods described in Ref [8]. The AI is a direct measure of the ionospheric activity.
8. The effective Sunspot Number is a parameter based on the predicted sunspot number used in conjunction with the SIRM ionospheric maps. The effective Sunspot Number is chosen to give the best fit between model (SIRM) calculation and actual measurements Ref [3].

These models reside on the DIAS server and are invoked to generate the maps of the ionospheric parameters and other information products. The DIAS products make use of the latest available ionogram data sets which reside on the DIAS server system. These real-time ionograms are automatically forwarded from the participating ionosonde stations.

DIAS results

The DIAS products available to specify the current conditions of the ionosphere over Europe include:

- Real-time ionograms from the contributing DIAS stations in a common format
- Daily values and plots of scaled ionospheric parameters, e.g. the critical frequency of the F2 layer (foF2), the lowest frequency reflected by the ionosphere which appears on the ionogram (fmin), the ratio of the maximum reflected frequency from the F2 layer over a 3000km range to the critical frequency of the layer (M(3000)F2), etc.
- Profiles of electron density versus height over each contributing DIAS station
- Regional maps showing the variation of relevant ionospheric parameters over the European area (i.e. maps of foF2, M3000F2, Maximum Usable Frequency (MUF) and electron density (Ne) at various specified heights)
- Daily plots of the Effective Sunspot Number which give estimates of the best fit between the Simplified Ionospheric Regional Model (SIRM) and the foF2 measurements from the DIAS sounder grid.
- Activity Index for foF2 providing an alert for current ionospheric disturbances.

Figure 1 presents an ionogram from Athens Digisonde in DIAS layout. The results of the automatic scaling are also given. Figure 2 is an example of a regional foF2 nowcasting map which has been generated using the ionospheric data from the DIAS sounders. The MUF produced assuming that the transmitting antenna is located in Madrid is given in Figure 3. Within DIAS a number of maps of this type are available covering the

European region. DIAS users are also provided with a web interface which allows individual predictions to be generated according to the users' needs.
Figure 4 shows an example of the electron density map for a specific height. For this product, height is user-specified.

The products available in the Short-term Forecasts category include:

- Short-term ionospheric predictions (for periods of one to 24 hours ahead over Europe)
- European maps of Ionospheric Alert Indices for the foF2 which provide warnings for forthcoming disturbances.

The products available in the Long-term Predictions category include:

- Long-term ionospheric predictions (maps for the European area of foF2, M3000F2, and MUF)

Long-term prediction maps are available in the same format as the short-term nowcast and forecast maps shown in Figures 2 & 3.

Archived ionogram data is stored in the Standard Archiving Output (SAO) format which is ASCII text-based and readily accessible. The information and map products are presented in text and image formats.

On-line access to all available DIAS products and services is currently free to all registered users, directly through the DIAS system (http://dias.space.noa.gr) or indirectly through the DIAS project web site (http://www.iono.noa.gr/DIAS) for users who are not registered yet.

DIAS users' network

A network between the DIAS data providers and the users from the research, academic and industrial sector has been established. Continuous updates on the latest DIAS developments have been communicated through the circulation of monthly e-newsletters. Several meetings have been organised where evaluation discussions on the current version of DIAS prototype were held and contacts with all the members have been established through systematic surveys inside the DIAS network. This intense activity resulted to the identification of the avenues for the commercial exploitation of the DIAS products and services. The potential market sectors into which DIAS is able to supply its products and services have been identified and ranked according to their needs for specific DIAS products and to the existing competitive data sources. According to this ranking, the top users of the DIAS products are the defence industry, the civil aviation, the upper atmosphere researchers, the civil HF broadcast and the radio amateurs. Possible approaches to marketing were determined and possibilities for future development of DIAS have been considered in order to ensure the viability of the system in long-term future.

Conclusions

DIAS is the first Europe-wide project aiming at the collection of ionospheric observations from the European ionosondes and the development of added-value products for radio propagation services. The major strength of DIAS is that it can easily integrate new sets of observations in other areas around the world, can be easily updated by newly developed models and can follow the latest technological advance. These are the elements that enable the evolution of DIAS services over the next years and therefore ensure a long term future. In the near future DIAS could posibly expand its services through collaboration with existing ionospheric service providers on other continents, improving the accuracy for the worldwide specification of the ionosphere and contributing to the development of more accurate products for ionospheric prediction.

Acknowledgements

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References

[1] A. Belehaki, L. Cander, B. Zolesi, J. Bremer, C. Juren, I. Stanislawska, D. Dialetis, M. Hatzopoulos. "DIAS Project: The establishment of a European digital upper atmosphere server", Journal of Atmospheric and Solar-Terrestrial Physics, 67, pp. 1092-1099, (2005).

[2] B. Zolesi., Lj.R.Cander, G. de Franceschi. "Simplified Ionospheric Regional Model for telecommunication applications", Radio Science, 28 (4) ,pp. 603-612, (1993).

[3] B. Zolesi., A. Belehaki, I. Tsagouri, Lj.R.Cander. "Real-time updating of the Simplified Ionospheric Regional Model for operational applications", Radio Science, 39, RS2011, (2004).

[4] Stanisławska, I., G. Juchnikowski, and Z. Zbyszyński, "Generation of instantaneous maps of ionospheric characteristics", Radio Sci., 36(5), p1073, 2001.

[5] Muhtarov, P., I. Kutiev, and Lj. R. Cander, "Geomagnetically correlated autoregression model for short-term prediction of ionospheric parameters", Inverse Problems, 18, .p49, 2002.

[6] Koutroumbas,K. and A. Belehaki, "One-step ahead prediction of foF2 using time series forecasting techniques", Annales Geophysicae, 23, 3035-3042, 2006.

[7] Dominici, P., and B. Zolesi, "A model for the normal ionosphere over Rome", Nuovo Cimento C Serie 1, 10C, pp.191-208, 1987.

[8] Bremer, J. Lj.R. Cander, J. Mielich and R. Stamper, "Derivation and test of ionospheric activity indices from real-time ionosonde observations in the European region", submitted to JASTP, 2006.

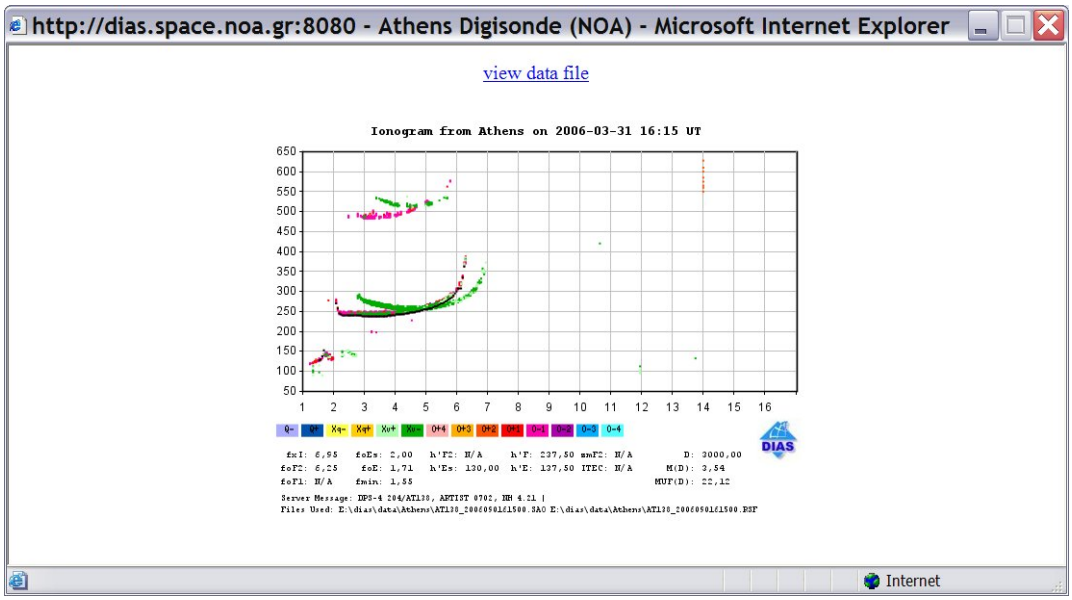

Figure 1: An ionogram from Athens Digisonde in DIAS layout. The results of the automatic scaling are also given. Clicking on the "View data file" the user can download the SAO file for the specific sounding.

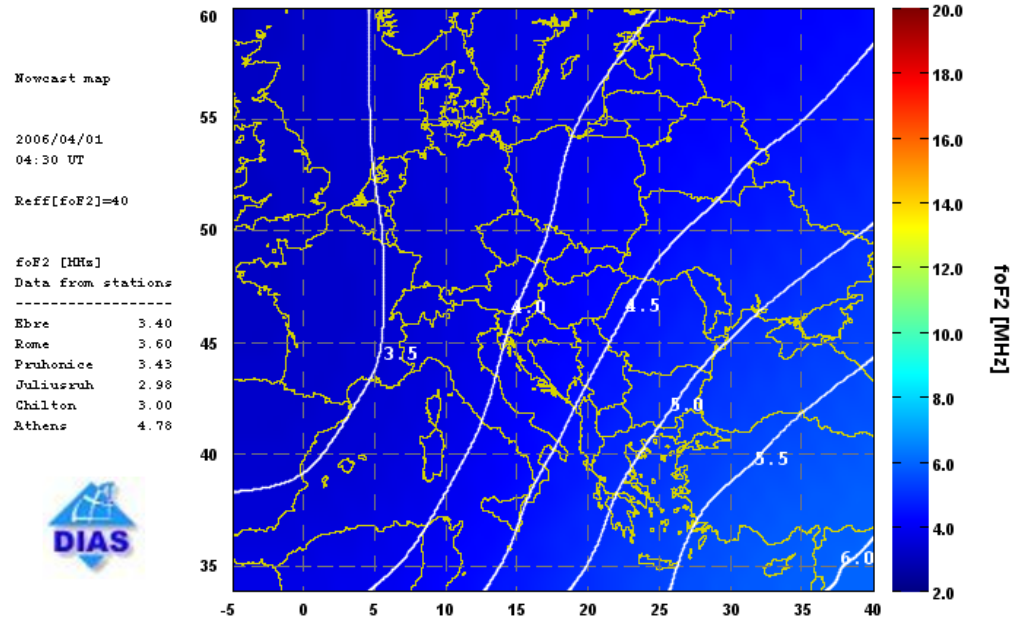

Figure 2: An example of a regional foF2 nowcasting map which has been generated using the ionospheric data from the DIAS sounders. The estimated value of the effective sunspot number as well as the real-time values of the foF2 parameter observed from the DIAS stations at the specific epoch is given on the left hand side of the figure.

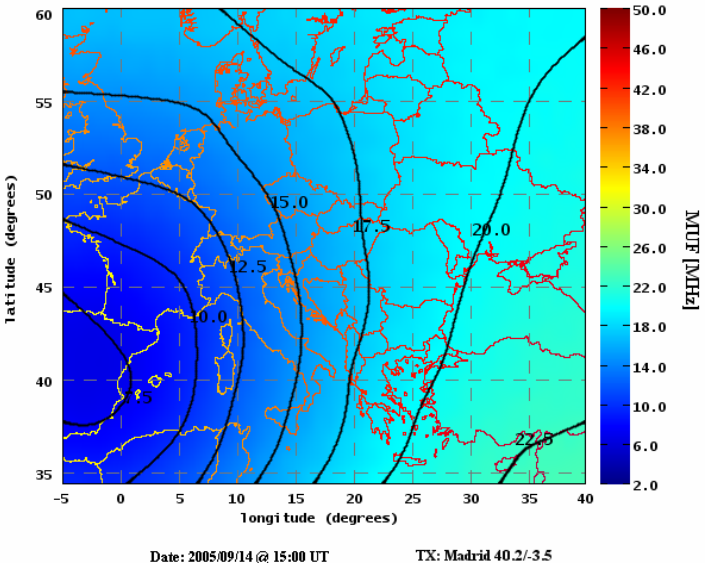

Figure 3: The MUF produced for nowcasting purposes, assuming that the transmitting antenna is located in Madrid.

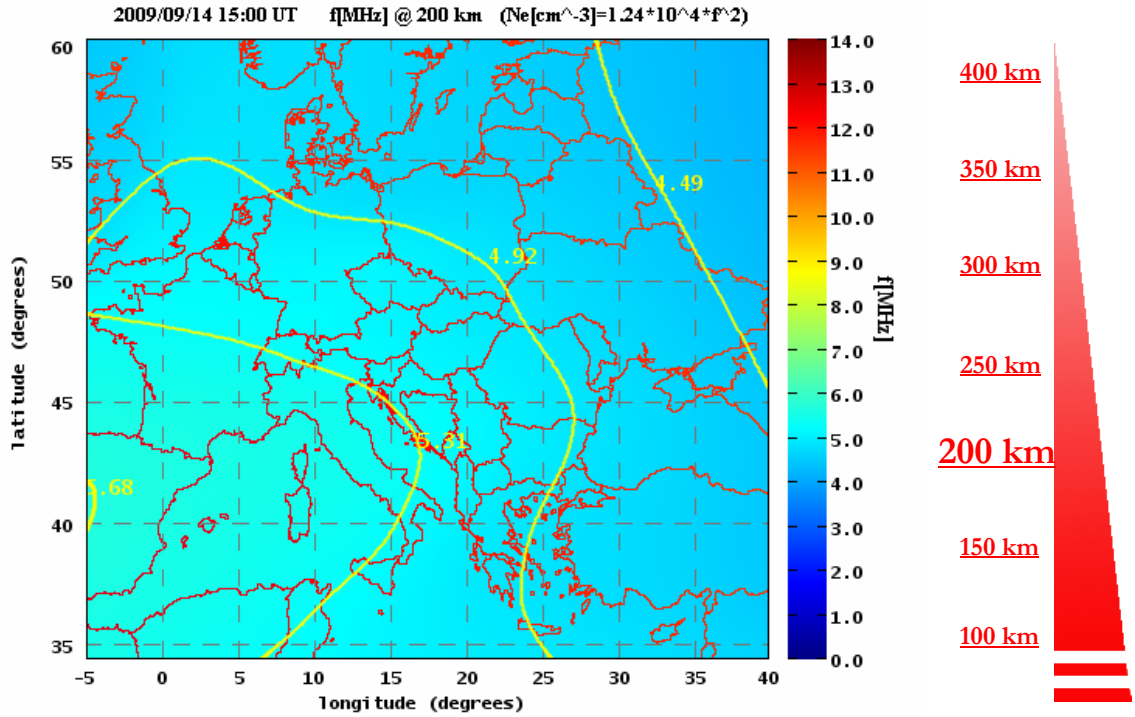

Figure 4: An example of the electron density nowcasting map over Europe at 200 km.

NATO IST056 "Characterizing the Ionosphere"
Fairbanks, Alaska, 12-16 June 2006

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Anna Belehaki (National Observatory of Athens, Greece)
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Christer Juren (Swedish Institute of Space Physics)
Iwona Stanislawska (Space Research Center, Polish Academy of Sciences)
Dimitris Dialetis (University of Athens, Greece)
Mihalis Hatzopoulos (University of Athens, Greece)

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European Digital Upper Atmosphere Server
DIAS

A European service for the specification and the prediction of the state of the ionosphere, funded by the *eContent* programme of the European Commission

DIAS consortium members and subcontractors

- National Observatory of Athens, Greece
  - BAE SYSTEMS, UK
- National Institute of Geophysics and Volcanology, Italy
- Leibniz-Institute of Atmospheric Physics, Germany
- University of Athens, Greece
- Rutherford Appleton Laboratory, UK
- Swedish Institute of Space Physics, Sweden
- Space Research Center, Poland
- Blustaff, Italy

DIAS data contributors

- Institute of Atmospheric Physics, Czech Republic
- Observatorio de l' Ebre, Spain

DIAS home page http://www.iono.noa.gr/DIAS

Objectives

- To develop a pan-European digital data collection on the state of the upper atmosphere based on historical data collections and on the real-time information provided by several European ionospheric stations.
- To develop a new digital server for the management and distribution of this collection, based on cutting edge technologies.
- To develop added value products and services for ionospheric specification and forecasting that best fit the needs of the market and to perform all necessary actions for the efficient promotion of this pan-European digital data collection to the European and worldwide market.

DIAS home page http://www.iono.noa.gr/DIAS

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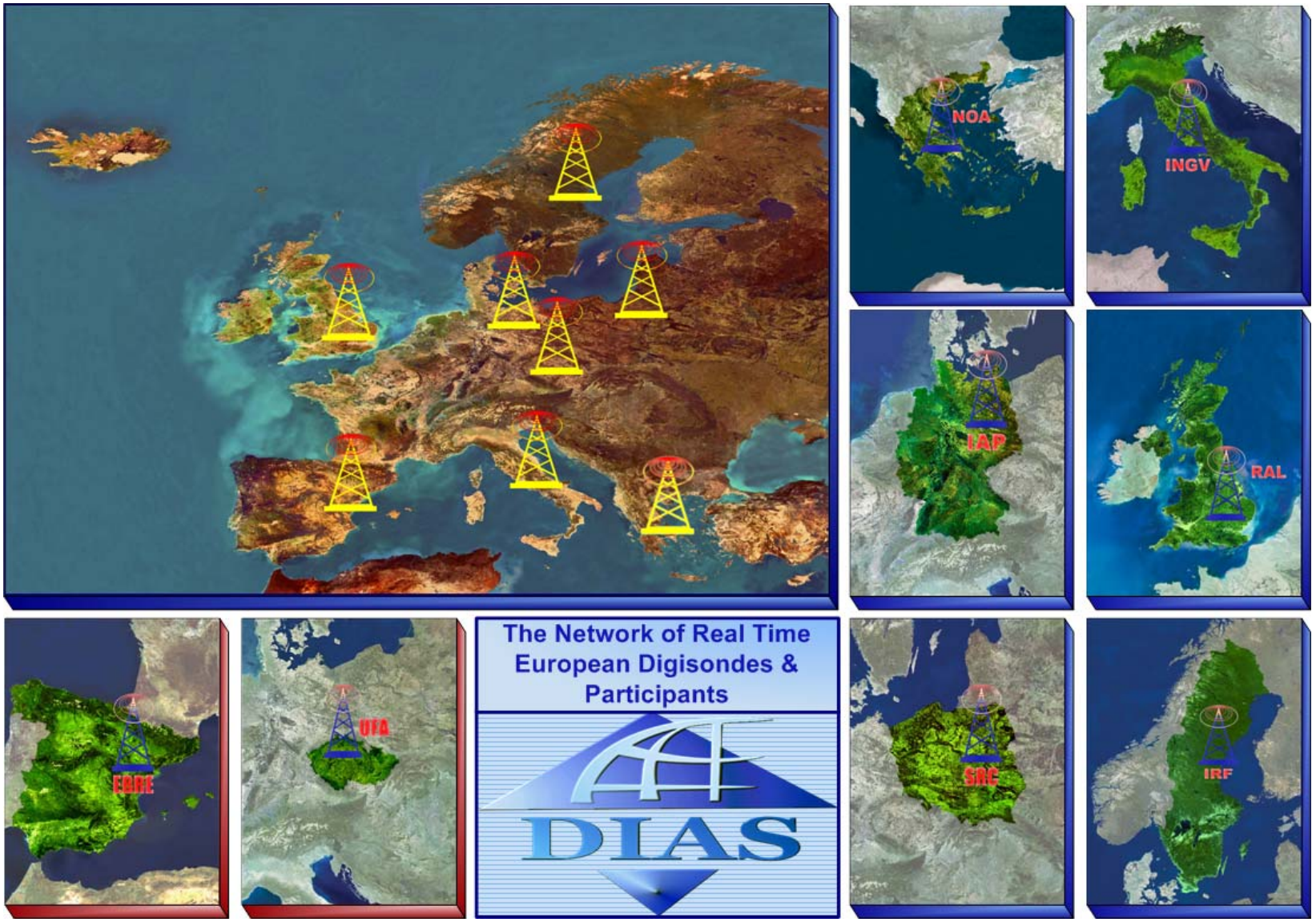

The basic DIAS data products

- **Real-time and archive ionograms, and SAO files**: the raw outputs from the ionosondes;
- **Scaled parameters**: specific numbers from ionograms that describe the ionospheric features of interest.
- **Real-time f-plots** of the standard ionospheric characteristics: **fmin, foF2 and M(3000)F2**.

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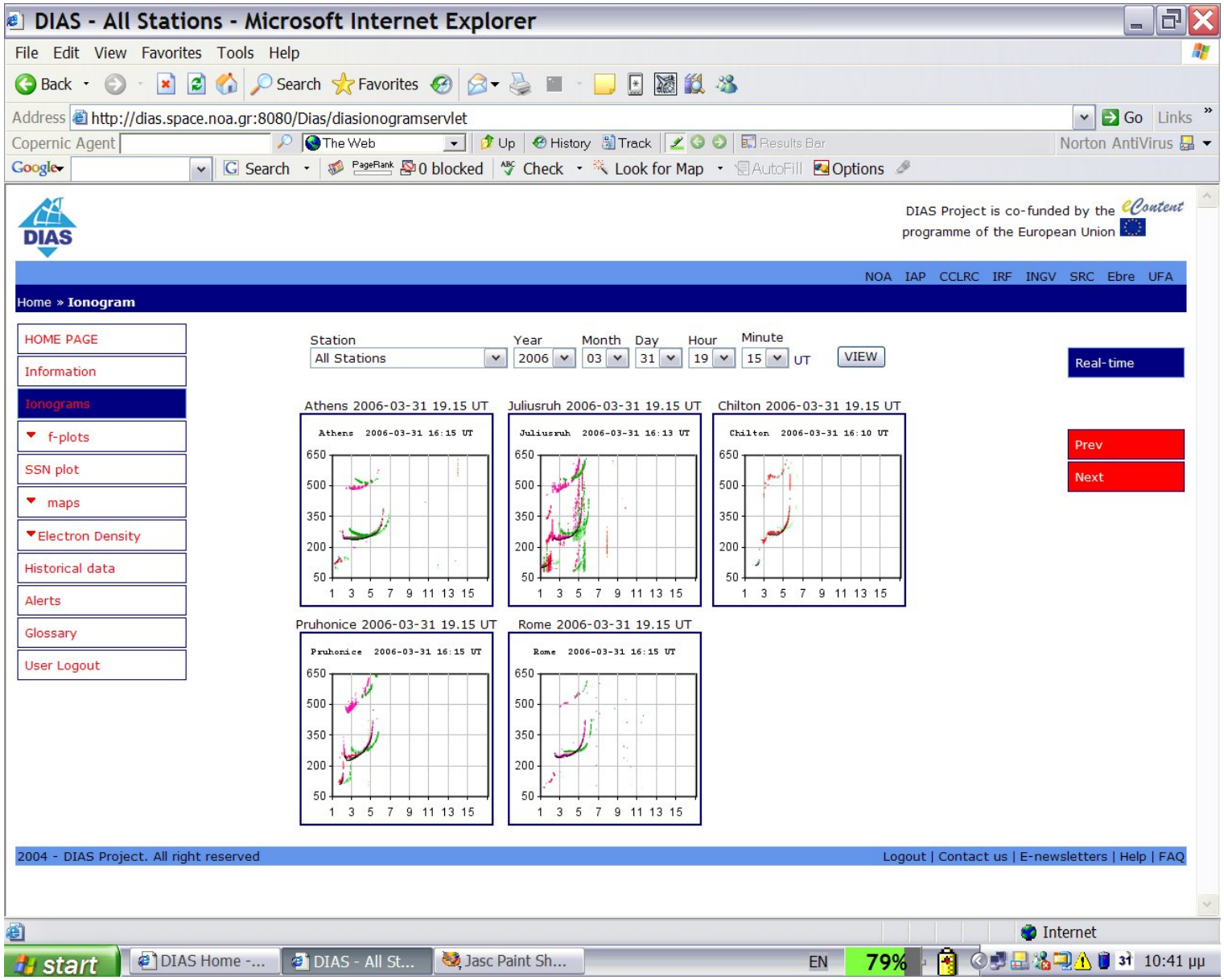

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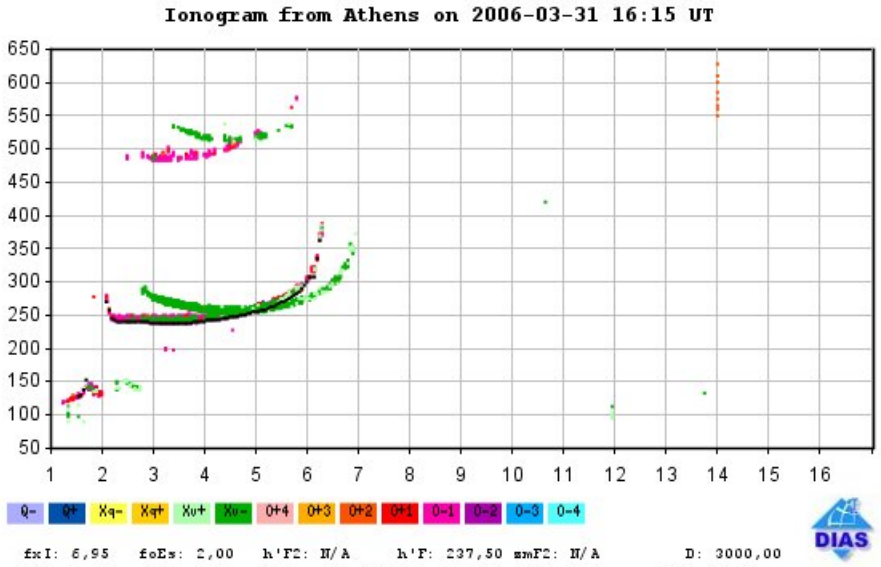

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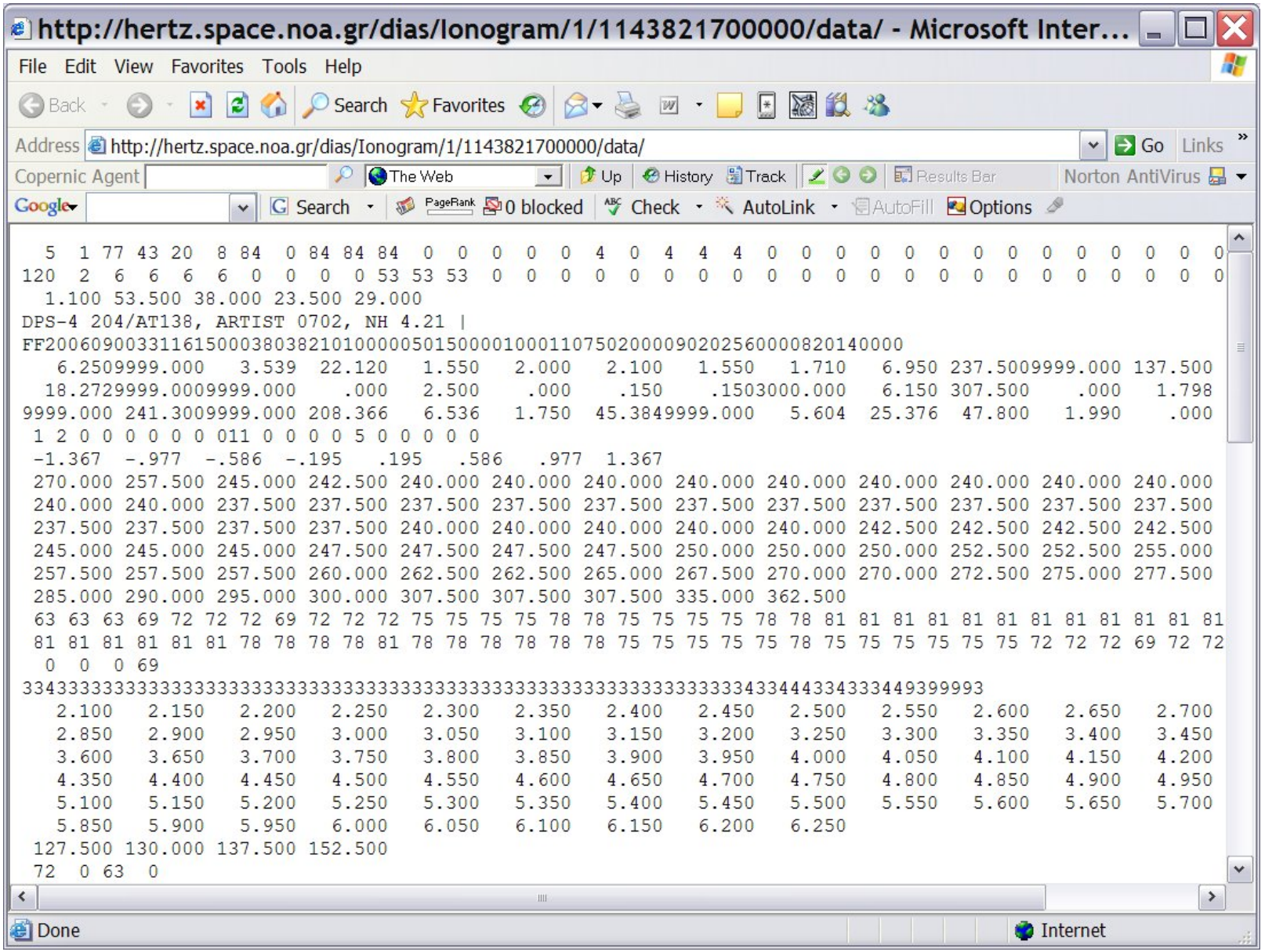

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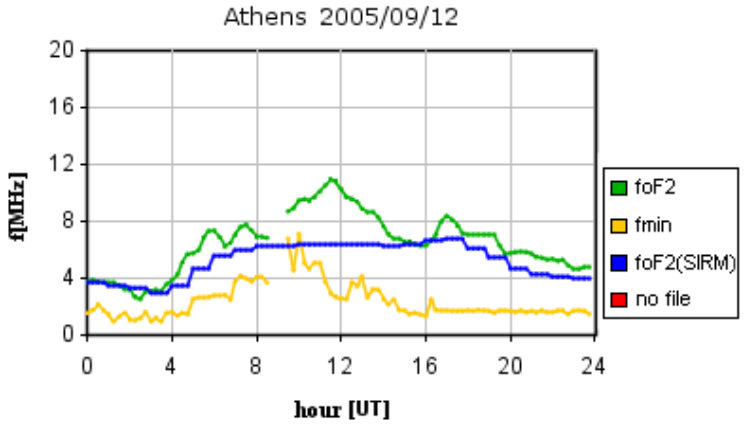
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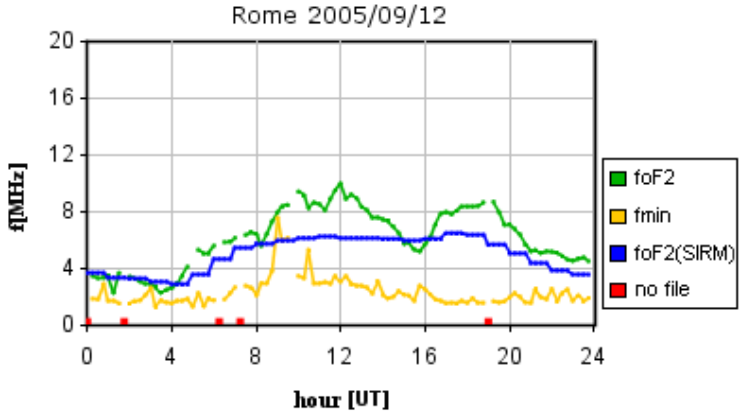
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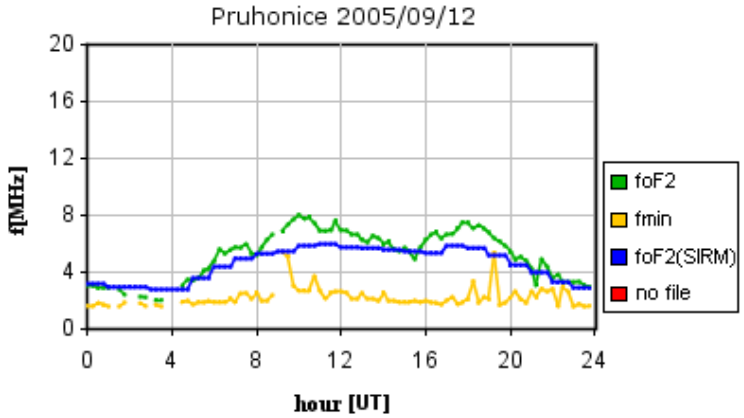
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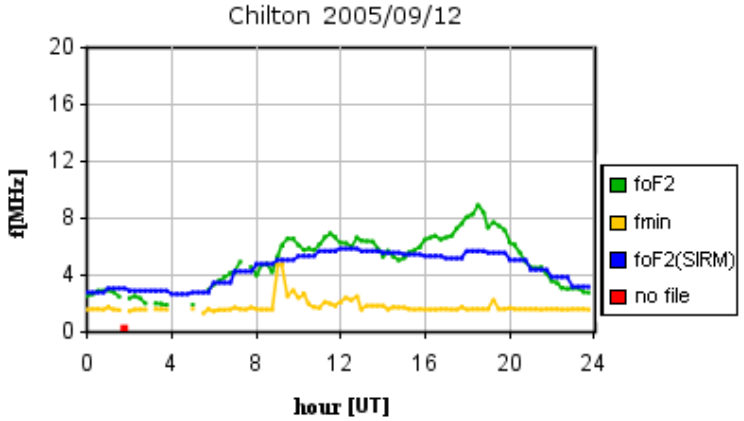
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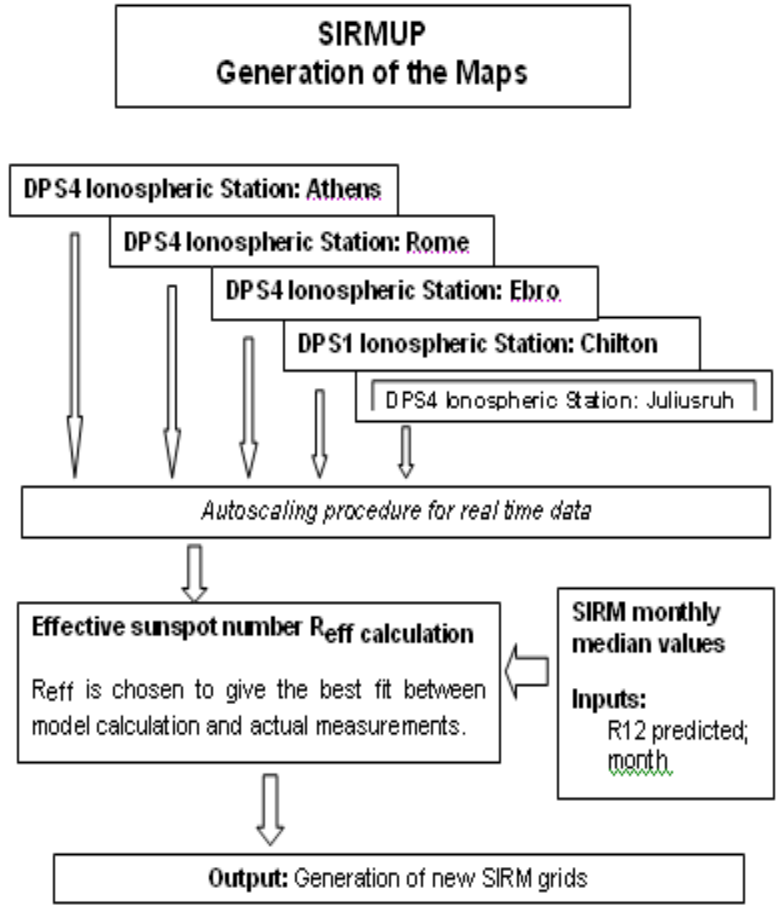
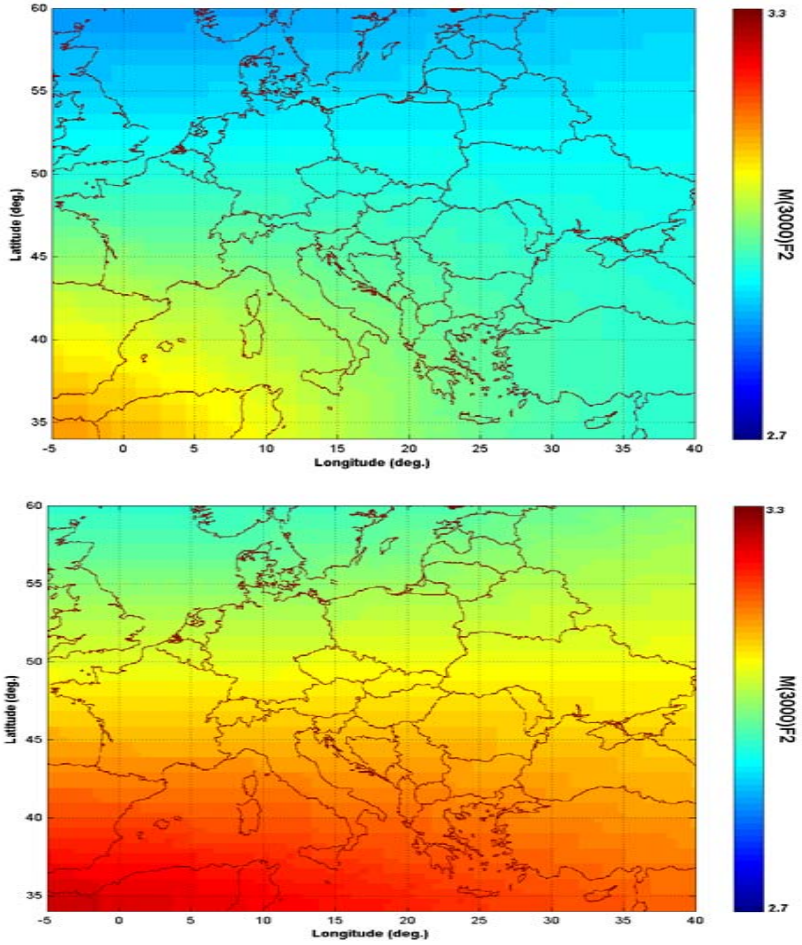
DIAS added value products:
1. Ionospheric specification and long term prediction

- Maps of the foF2 and M(3000)F2
- The hourly value of the effective sunspot number for the European area
- Maps of the MUF for different transmission points
- Electron density profiles over each station
- Maps of the electron density at different ionospheric heights

The ionospheric specification and long term prediction added value products and services offered by DIAS are based on:

- **S**implified **I**onospheric **R**egional **M**odel - **SIRM**;
- Real-time **up**dating of the **S**implified **I**onospheric **R**egional **M**odel - **SIRMUP**;
- Three dimensional instantaneous model of the ionospheric electron density - **Ne3D**;
- **MUF-SIRM&LKW** and **MUF-SIRMUP&LKW** maps of the basic Maximum Usable Frequency;





Maps of M(3000)F2 on 18 August 2001 at 0900UT generated by SIRM and SIRMUP.

Zolesi, B., Lj.R. Cander, and G. de Franceschi, Simplified ionospheric regional model for telecommunication applications, Radio Sci., 28(4), 603, 1993.

Zolesi, B., Lj.R. Cander, and G. de Franceschi, On the potential applicability of the simplified ionospheric regional model to different mid-latitude areas, Radio Sci., 31(3), 547, 1996.

Zolesi, B., A. Belehaki, I. Tsagouri, and Lj.R. Cander, Real-time updating of the Simplified Ionospheric Regional Model for operational applications, Radio Sci., 39(2), RS2011 10.1029/2003RS002936, 2004.

Tsagouri, I., B. Zolesi, A. Belehaki, and Lj. R. Cander, Evaluation of the performance of the real-time updated Simplified Ionospheric Regional Model for the European area, J. Atmos. Solar-Terr. Phys., 67(12), 1137, 2005.

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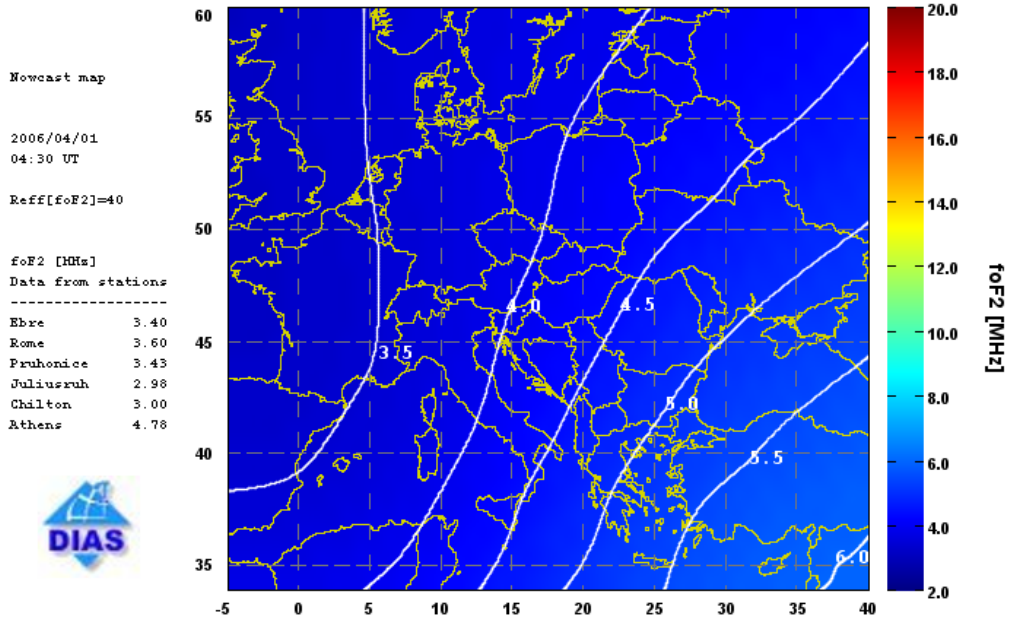
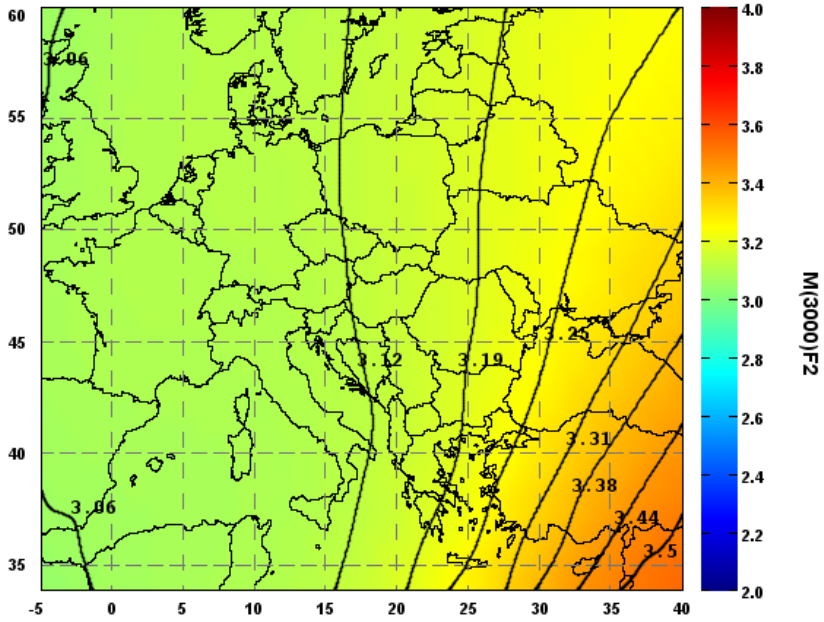
Nowcasting Maps of foF2 and M(3000)F2

foF2

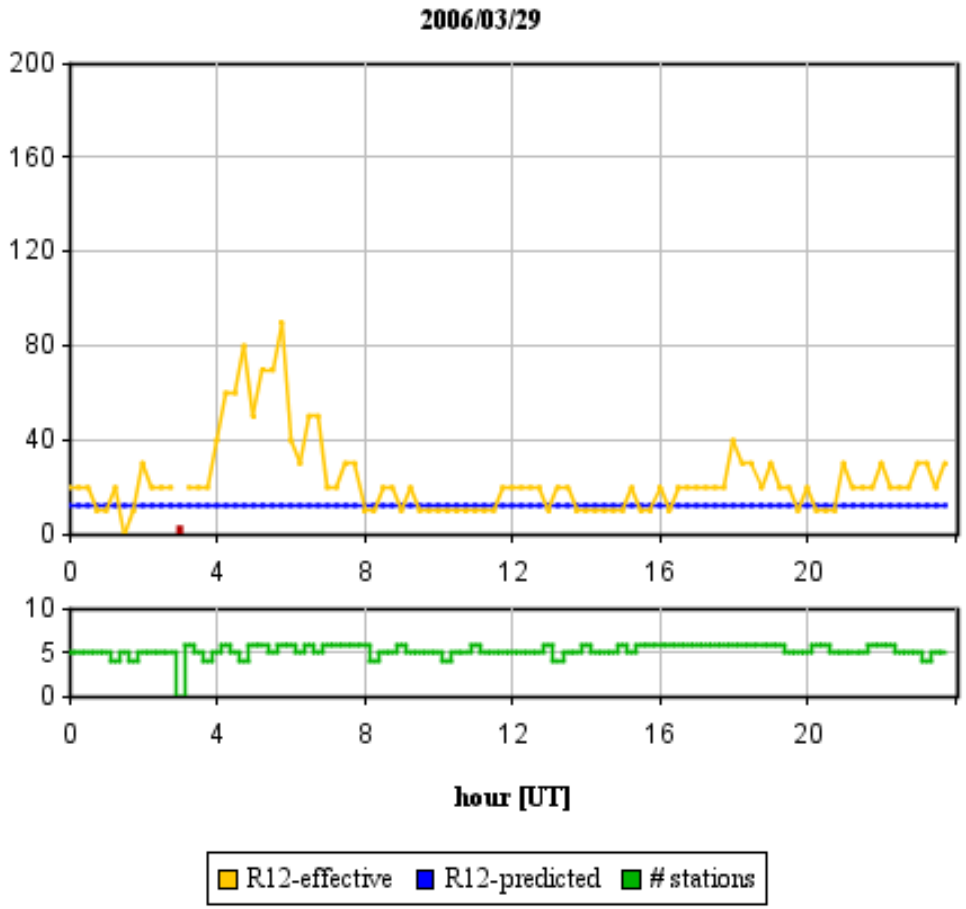


M(3000)F2



DIAS provides 24 hourly maps for monthly median long term prediction based on SIRM and near-real-time maps based on SIRMUP hourly updated

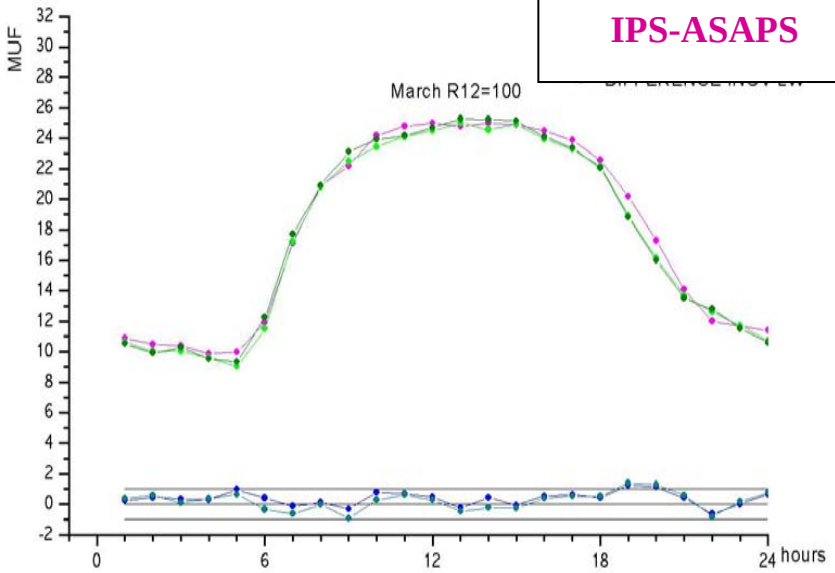
Daily plots of the Effective Sunspot Number

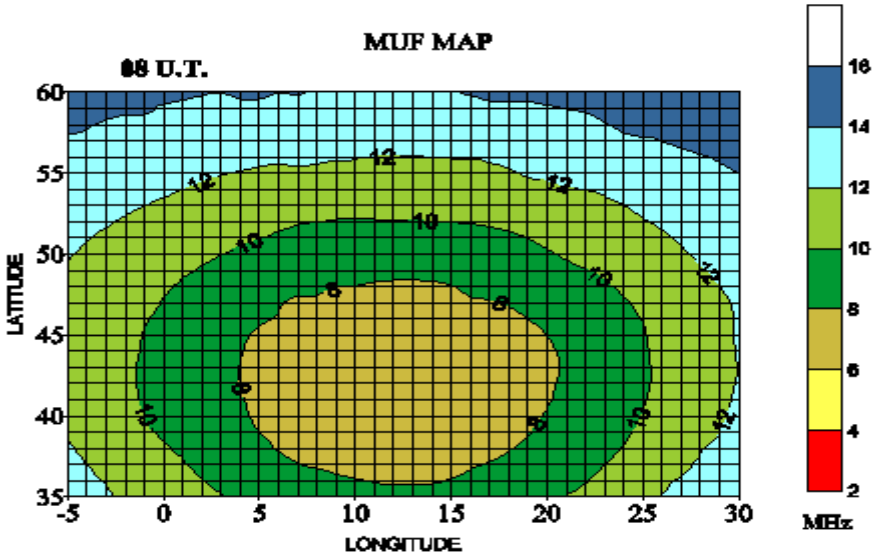


The effective sunspot number is the equivalent sunspot number reflecting the current ionospheric disturbances conditions over Europe and it is extracted by the SIRMUP model (Zolesi et al., Radio Science, 2004)

MUF-SIRM&LKW and MUF-SIRMUP&LKW maps of the basic Maximum Usable Frequency

SIRM& INGV
SIRM & LKW
IPS-ASAPS

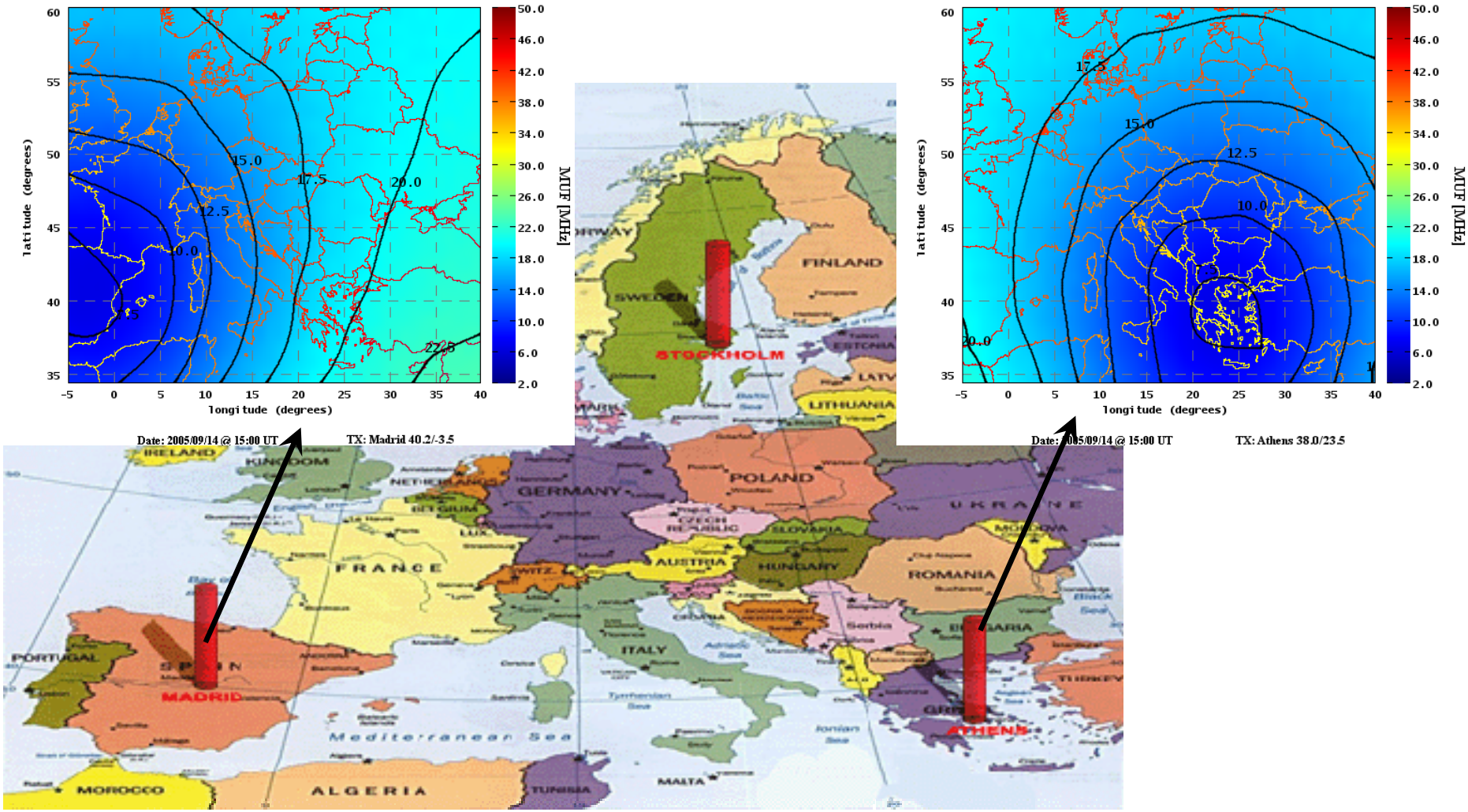




Example of MUF (MHz) map calculated for Rome as the point of transmission.

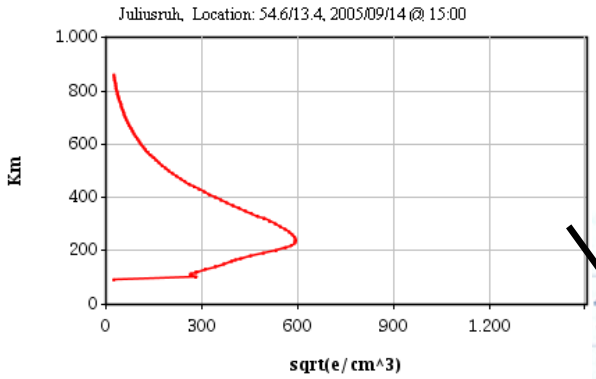
Monthly median values obtained by using
MUF prediction methods as IPS-ASAPS, SIRM&INGV and SIRM&LKW.

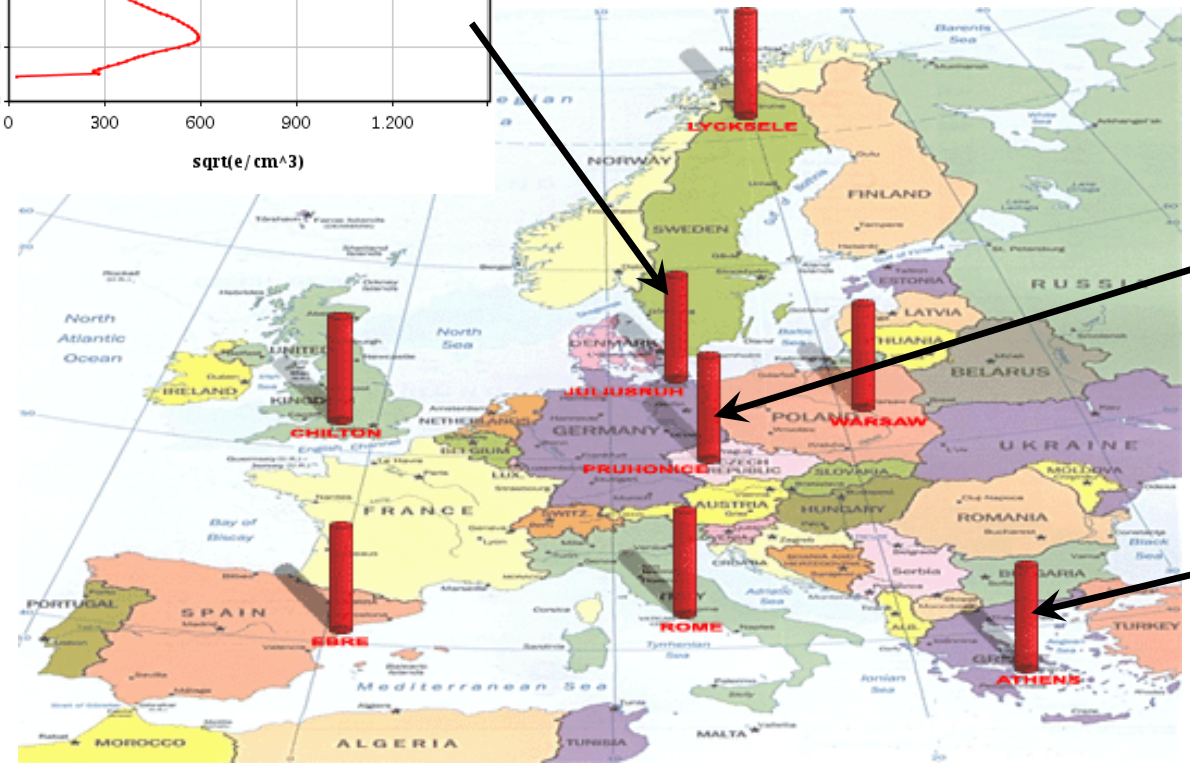
Nowcasting maps of MUF

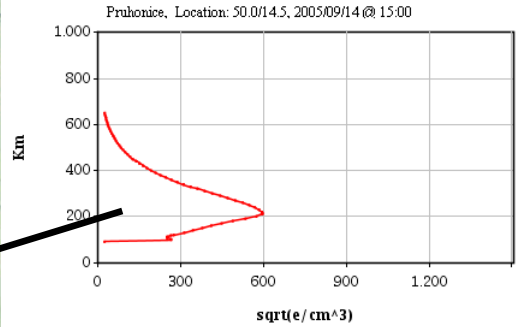


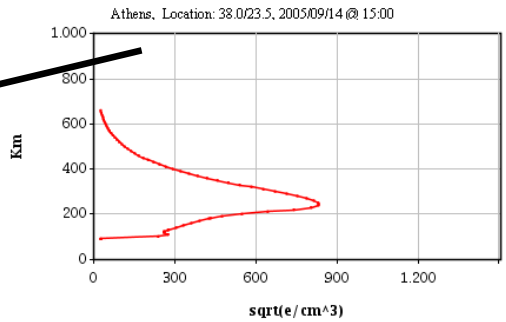
Electron density profiles over a single station

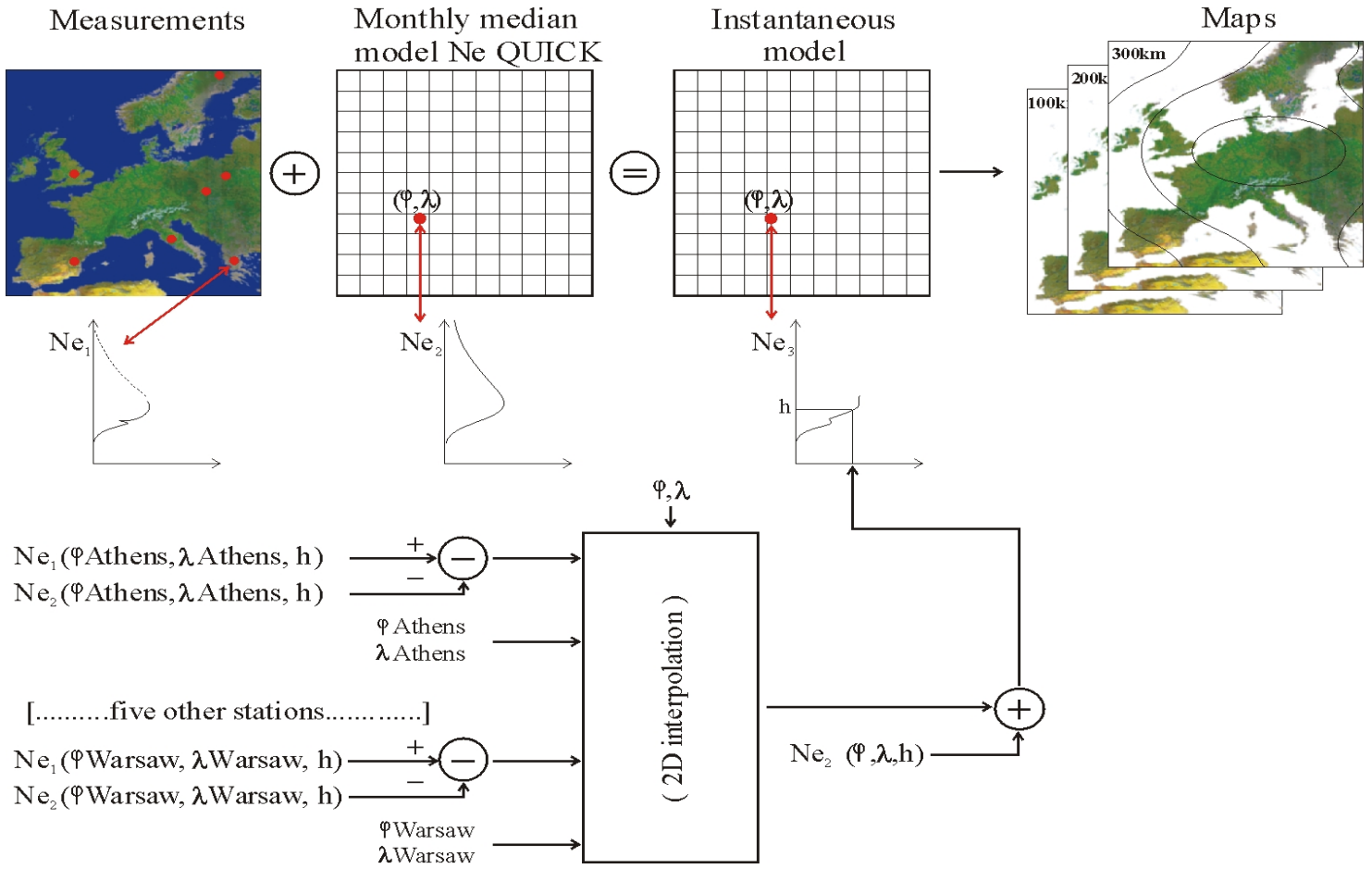
Reinisch and Huang (2001, ASR)
topside extrapolation method











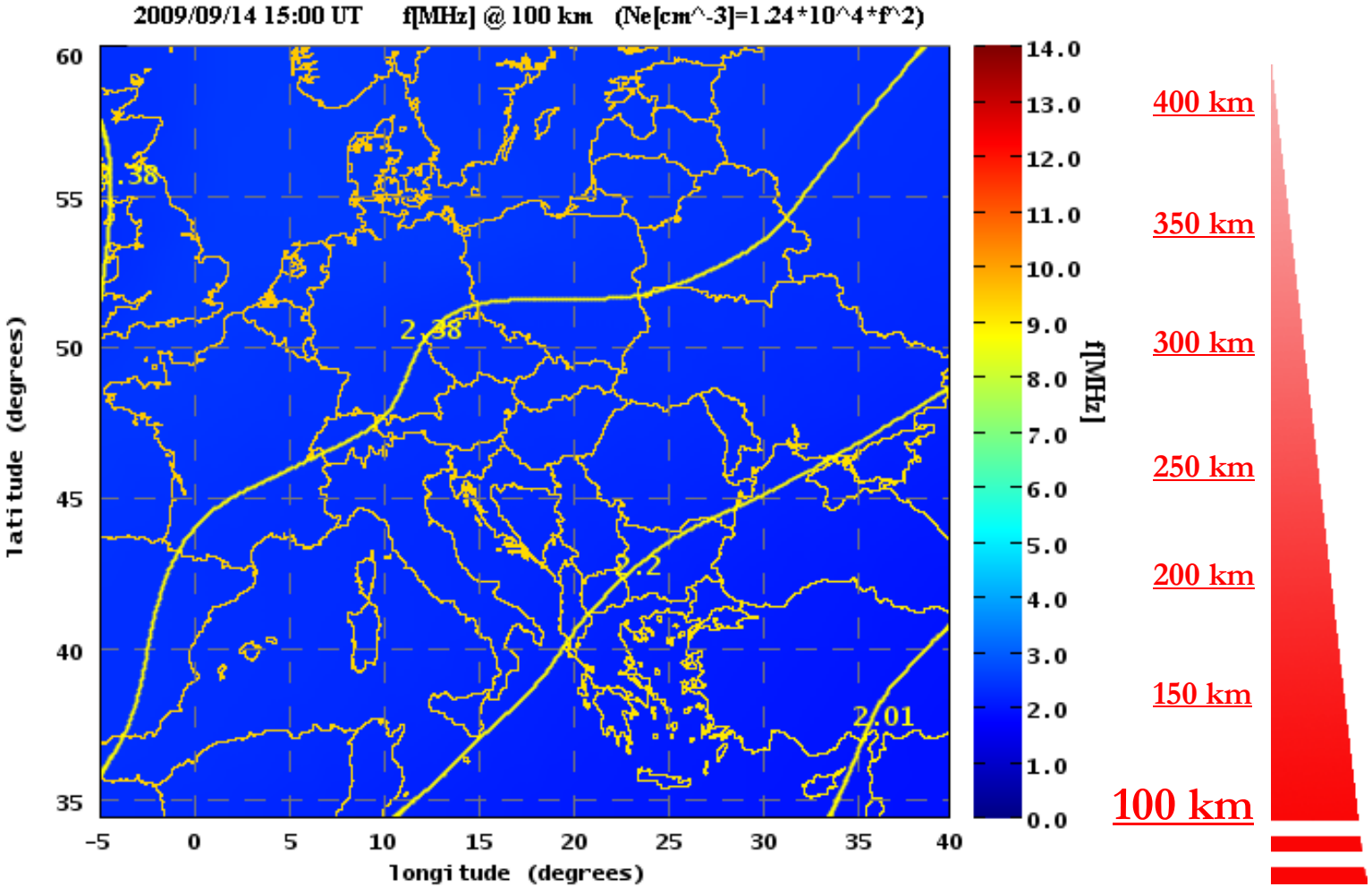
Ne3D: NeQuick – a statistical, monthly median model of Ne as a function of: time (month, hour), location (longitude, latitude), height and solar index R12 and Fitting – a multidimensional interpolation method which is used to combine measured values with the statistical model into one result.

Stanisławska, I., G. Juchnikowski, R. Hanbaba, H. Rothkaehl, G. Sole, and Z. Zbyszyński, COST 251 recommended instantaneous mapping model of ionospheric characteristics - PLES, Phys. Chem. Earth (C), 25(4), 291, 2000.

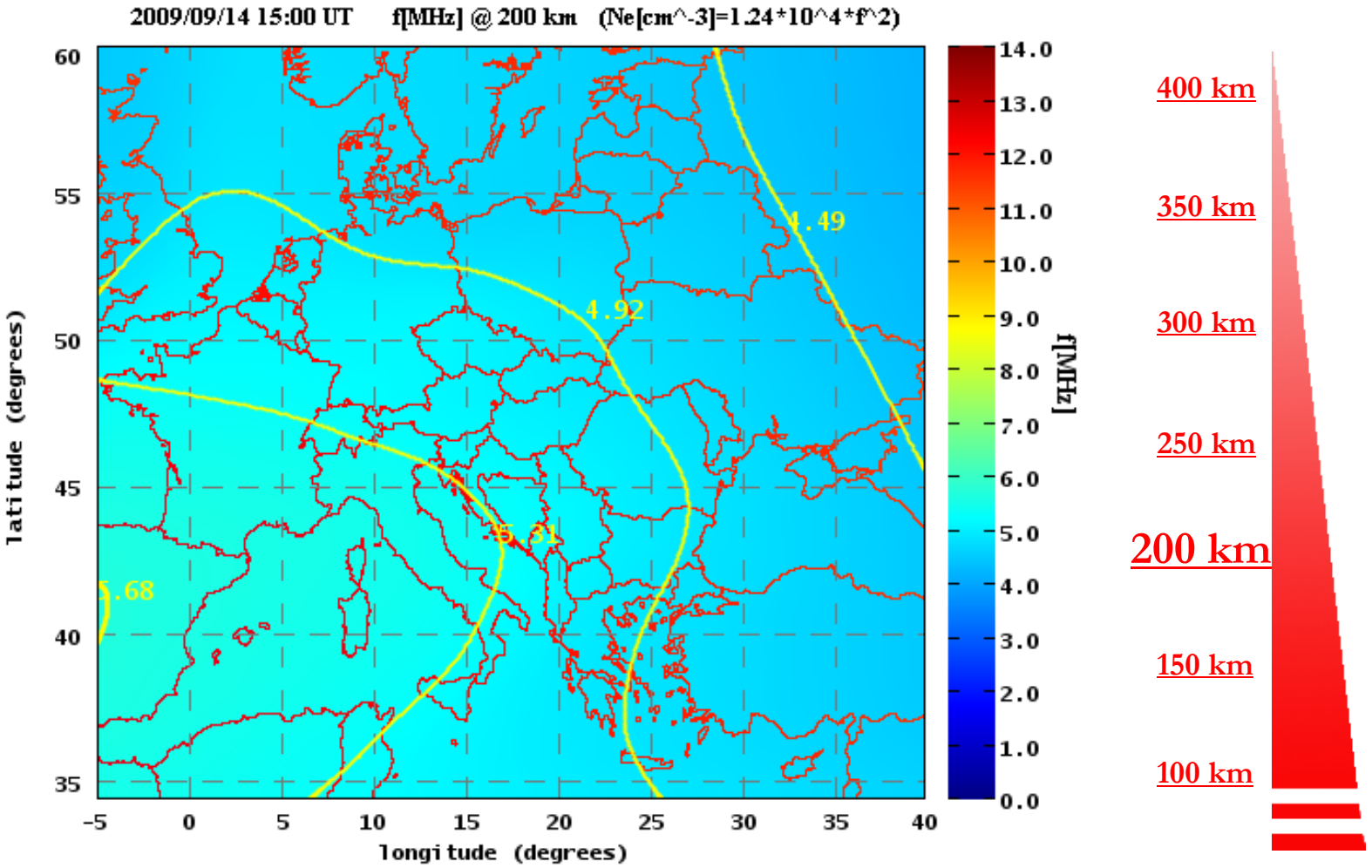
Stanisławska, I., G. Juchnikowski, and Z. Zbyszyński, Generation of instantaneous maps of ionospheric characteristics, Radio Sci., 36(5), 1073, 2001.

Stanislawska, I., H. Rothkaehl, and D. Bureshova, Limited - area electron concentration height profile instantaneous maps, Adv. Space Res., 33, 874, 2004.

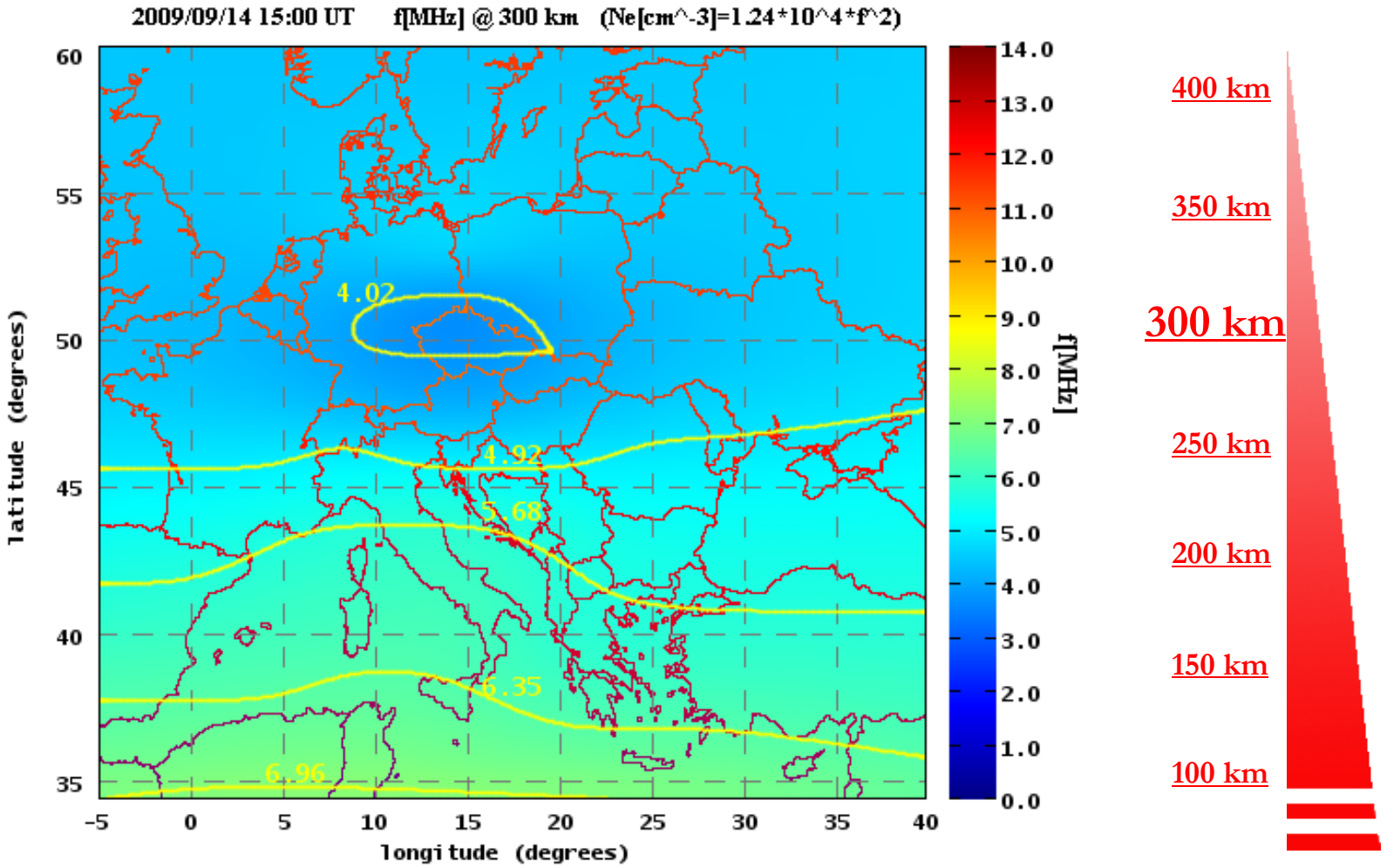
Nowcasting maps of Electron density



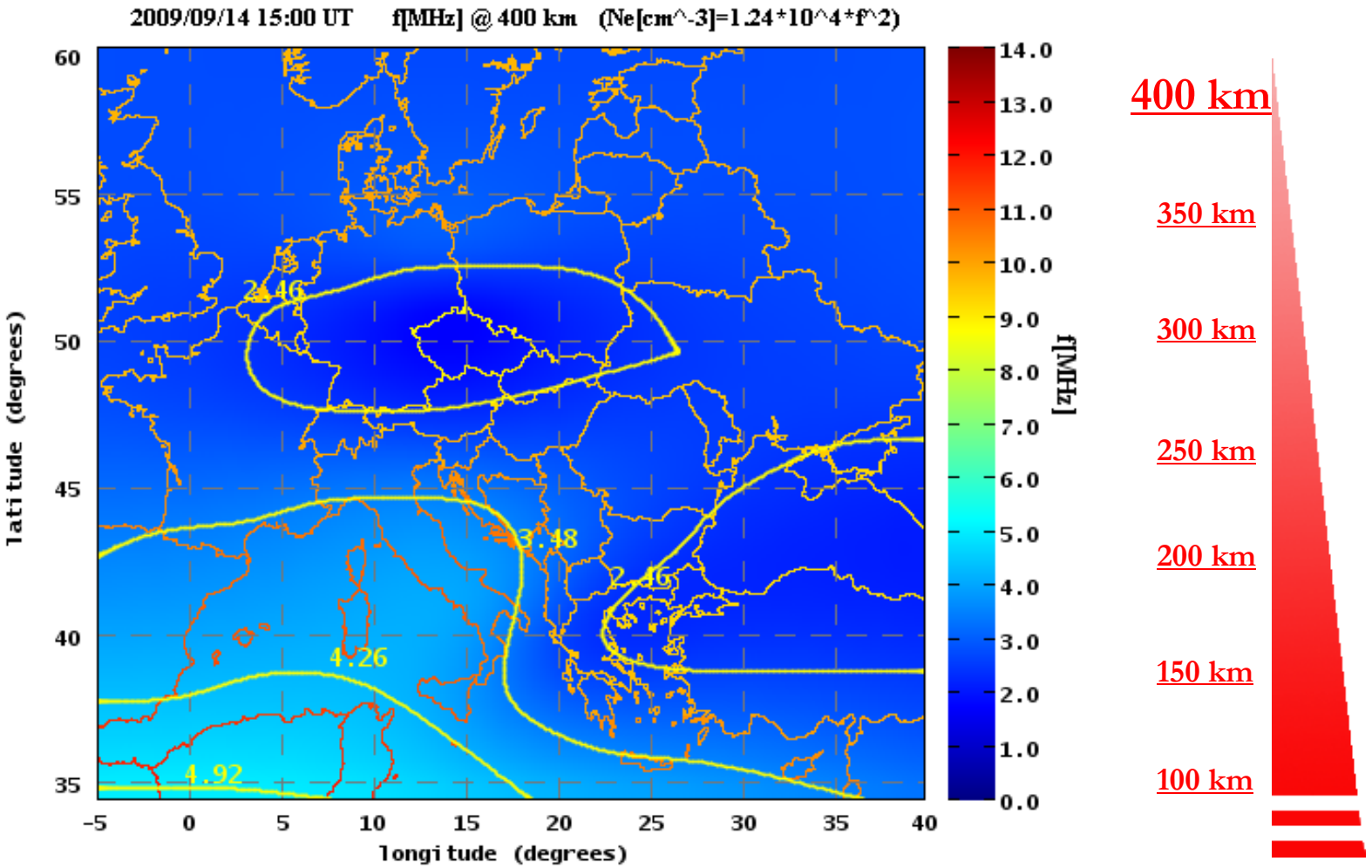
Nowcasting maps of Electron density



Nowcasting maps of Electron density



Nowcasting maps of Electron density



DIAS added value products:
2. Ionospheric short term forecast

- The value of the foF2 over each station up to 24 hour ahead
- European maps of the forecasted foF2
- Ionospheric Activity Index

Ionospheric short-term forecast models

Muhtarov, P., I. Kutiev, and Lj. R. Cander, Geomagnetically correlated autoregression model for short-term prediction of ionospheric parameters, Inverse Problems, 18, . 49, 2002.

Koutroumbas, K., and A. Belehaki. "Predicting foF2 using time series forecasting methods", Proc. of the 1st European Space Week, ESTEC, 2004.

Koutroumbas,K. and A. Belehaki, "One-step ahead prediction of foF2 using time series forecasting techniques", in press, Annales Geophysicae, 2006.

A. Belehaki, K. Koutroumbas, "Prediction of foF2 using AR-models", presented in the WP3 meeting of DIAS project, Rome, February, 2005.

K. Koutroumbas, A. Belehaki, "On the short-term estimation of the relative foF2", presented in the 3rd Technical Meeting of the DIAS project, Athens, 12-14 April, 2005.

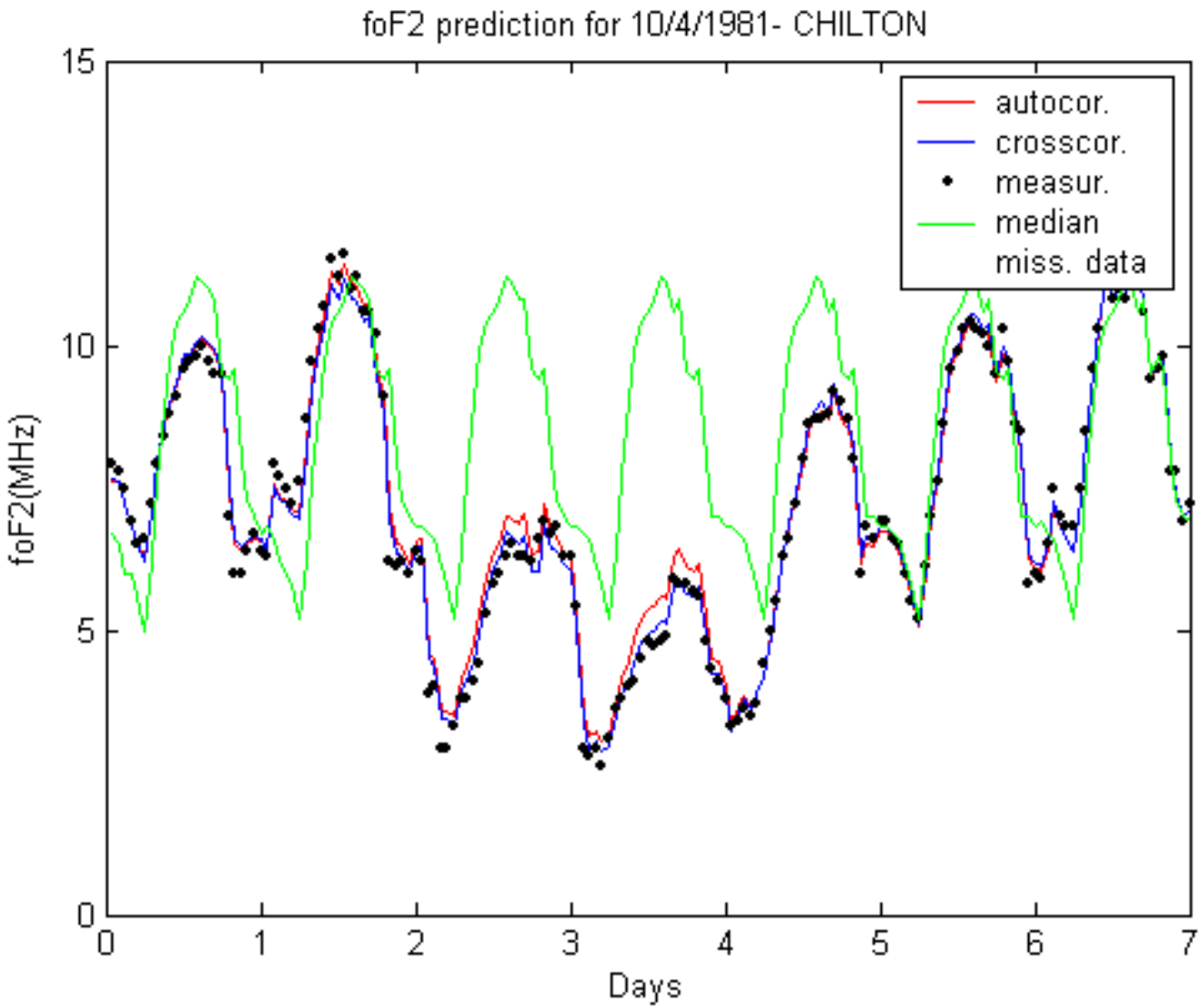
GCAM (Muhtarov, Kutiev and Cander, 2002)

It is an extrapolation model based on the weighted past data.

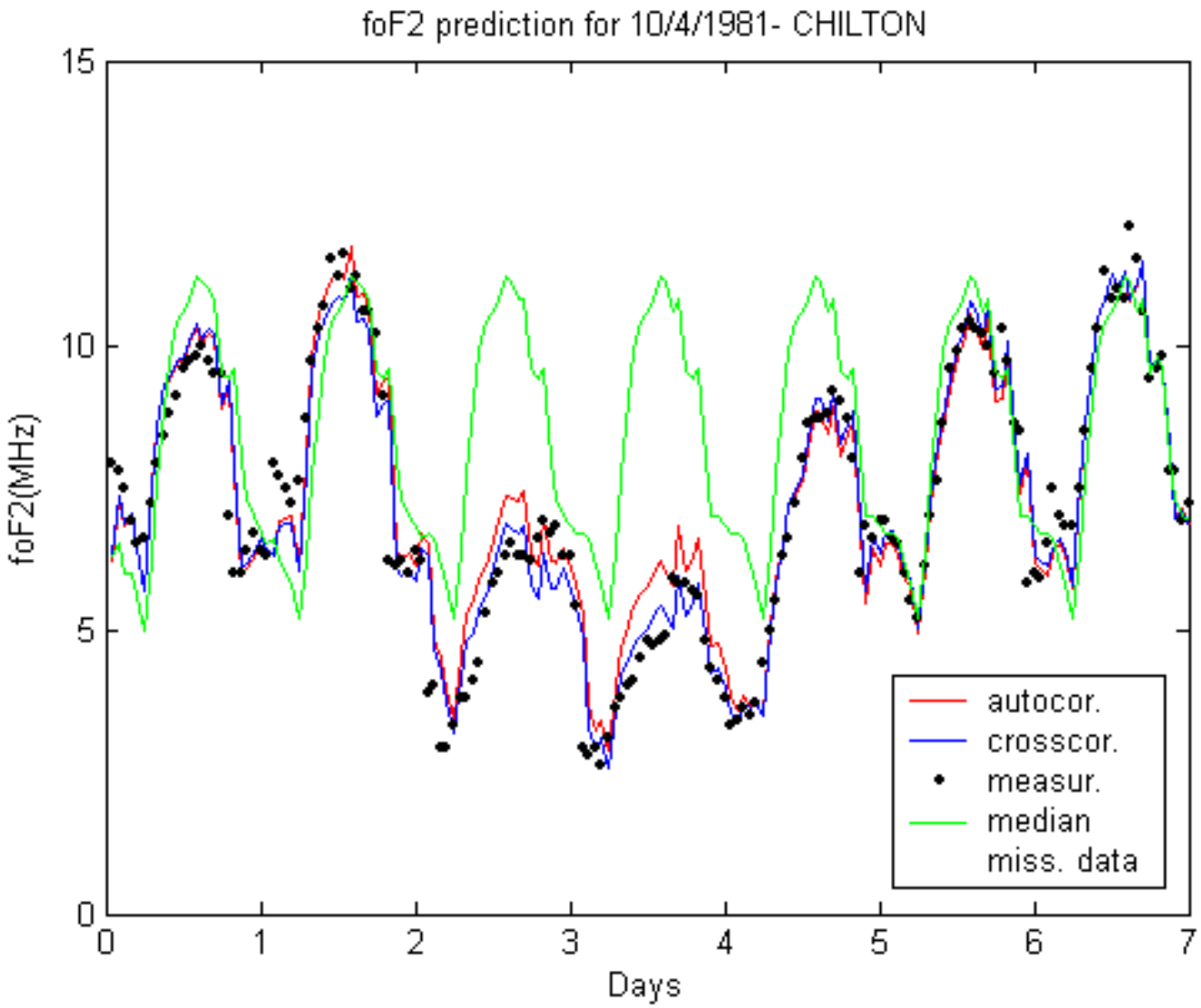
Predicted variable: Φ= (foF2obs – foF2median)/foF2obs

A new term in the regression equation expresses linearly the dependence of Φ on geomagnetic activity: Driving geomagnetic activity index (G), which expresses the expected average ionospheric deviation for a given hourly Kp level.

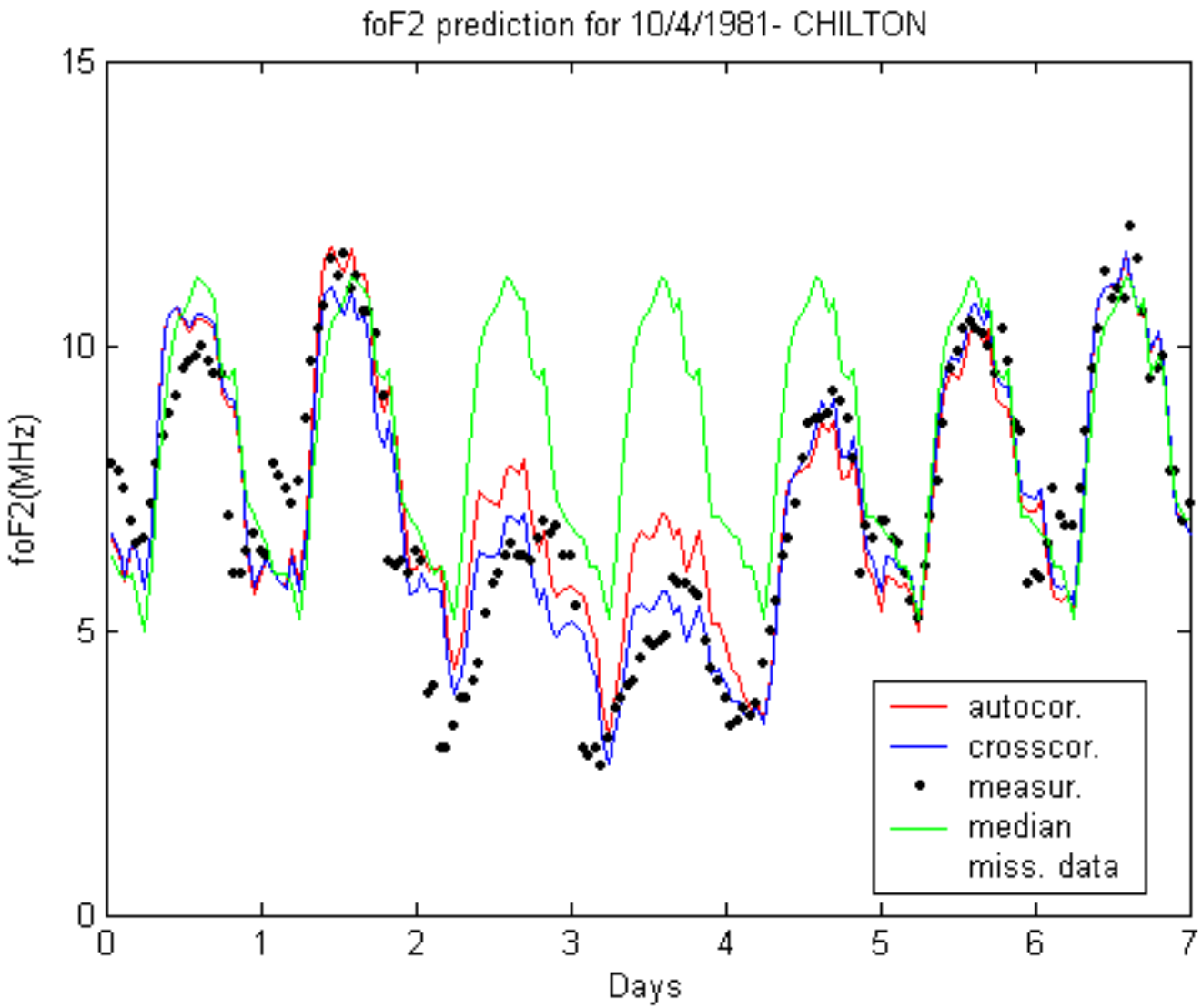
- Autocorrelation function of Φ for past 96 hours
- Autocorrelation function of G for past 96 hours
- Cross Correlation functions between Φ and G for the past 96 hours



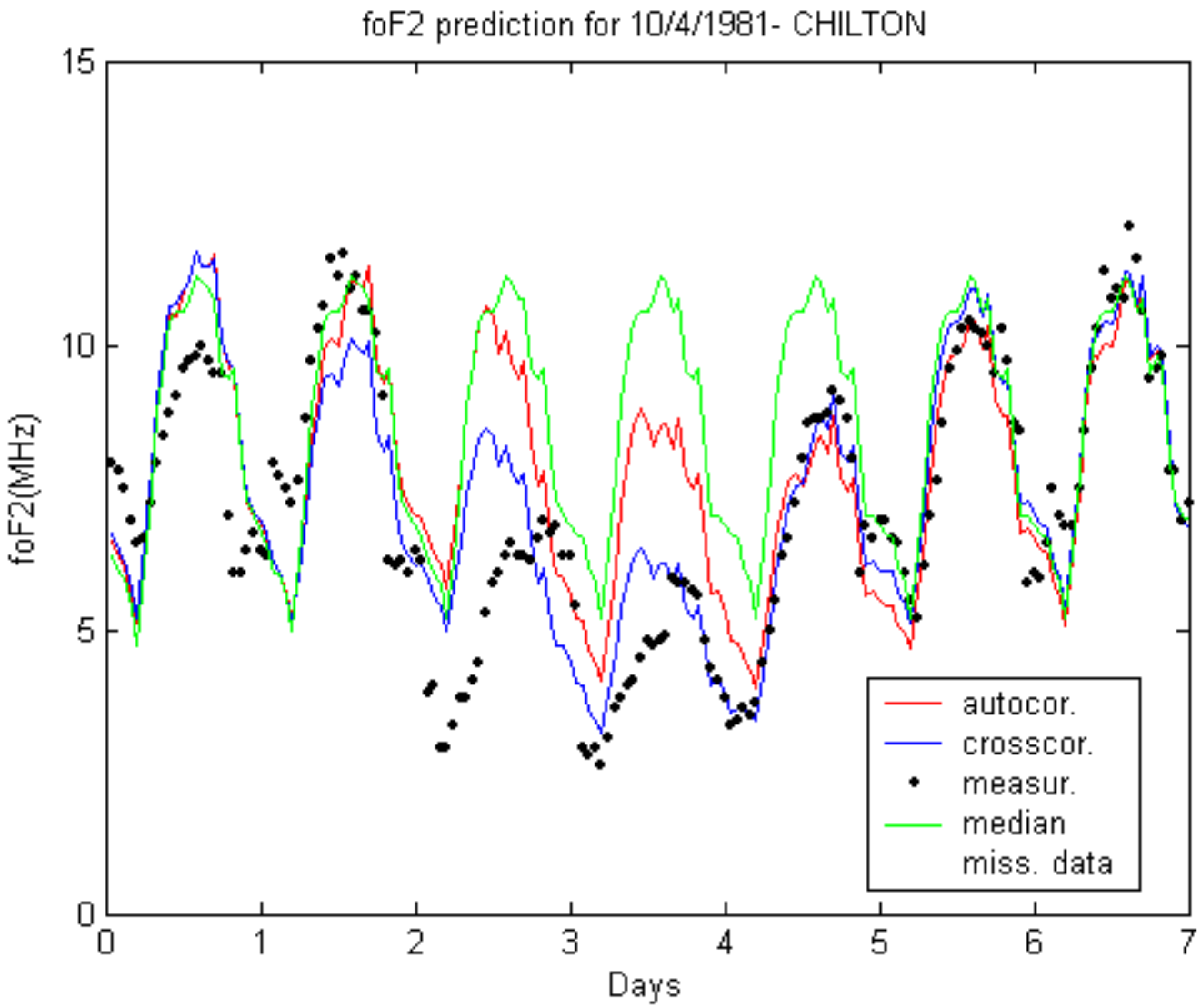
1 HOUR PREDICTION FOR 10-17 APRIL 1981 - CHILTON



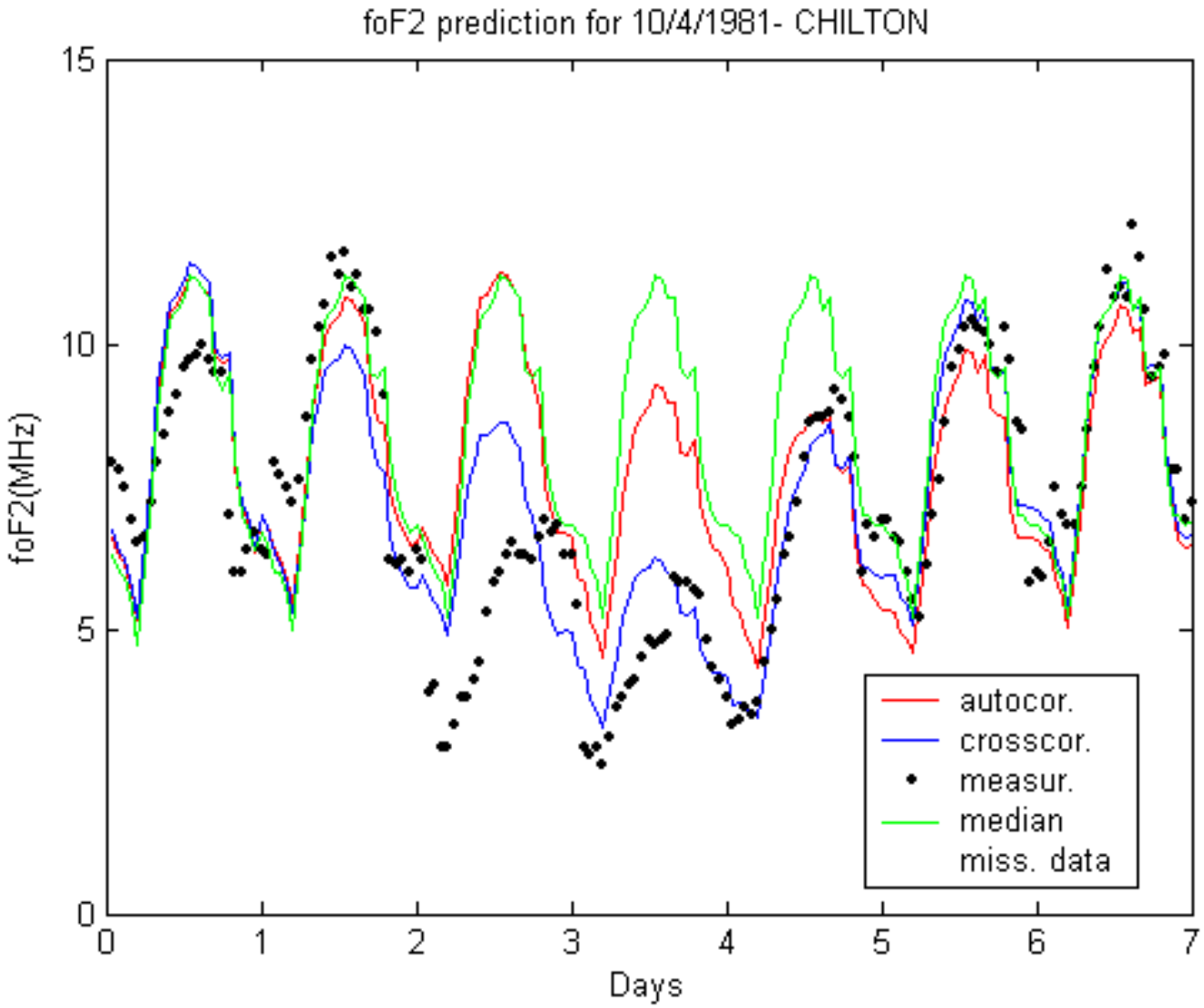
2 HOUR PREDICTION FOR 10-17 APRIL 1981 - CHILTON



4 HOUR PREDICTION FOR 10-17 APRIL 1981 - CHILTON



12 HOUR PREDICTION FOR 10-17 APRIL 1981 - CHILTON



24 HOUR PREDICTION FOR 10-17 APRIL 1981 - CHILTON

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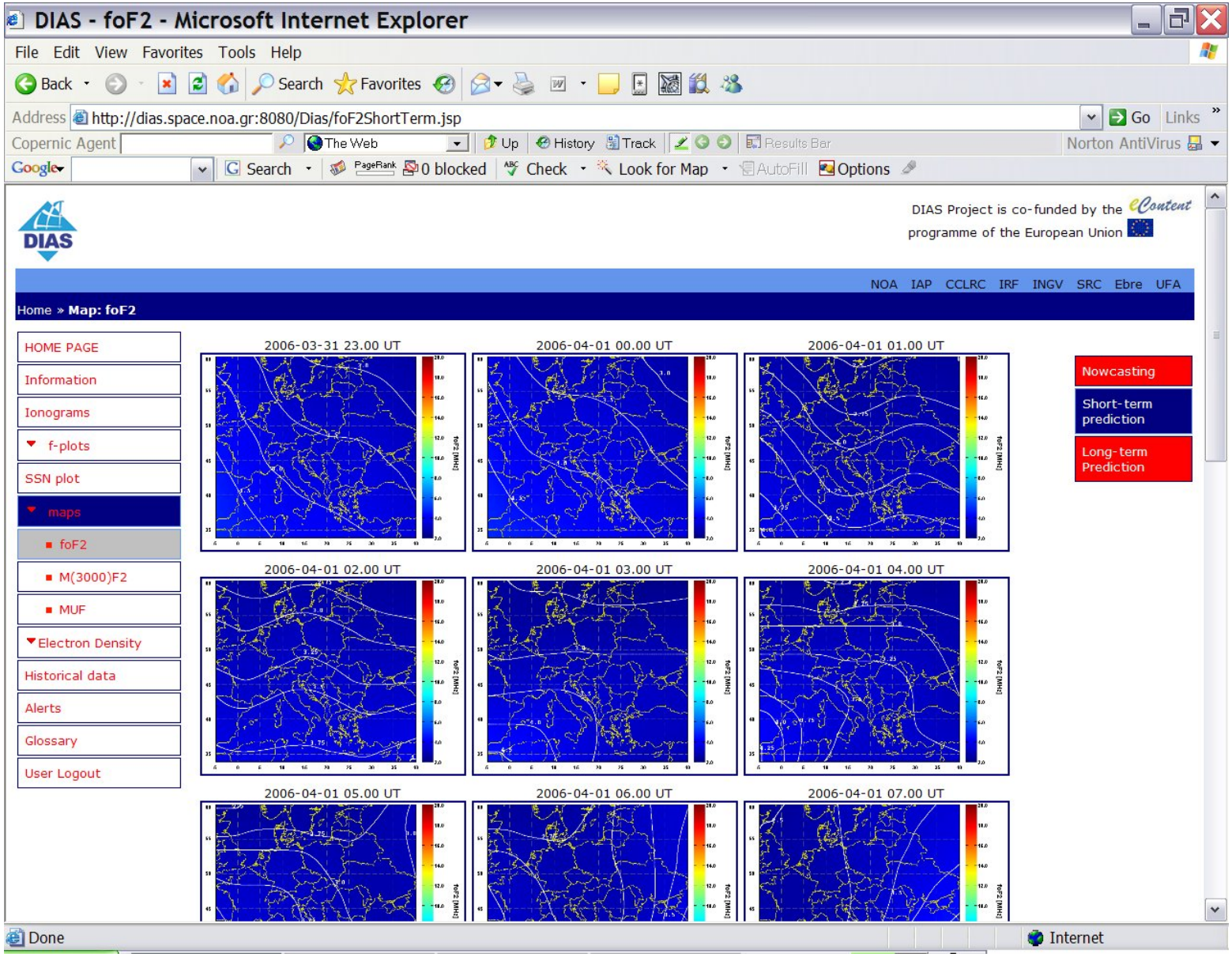
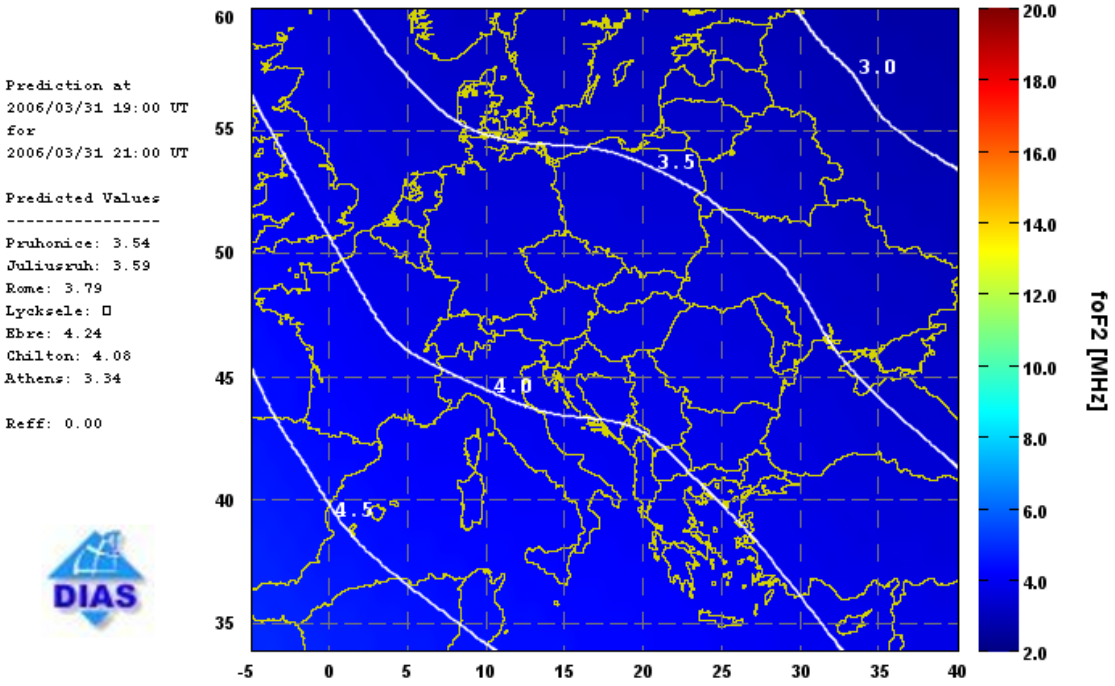
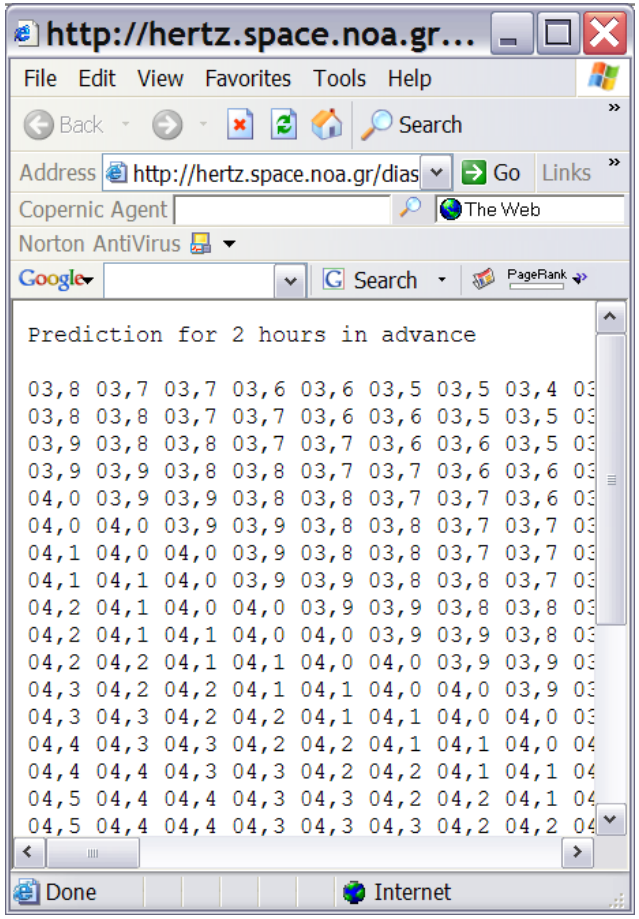


view data file





Ionospheric Activity index (AI) for real-time monitoring ionospheric propagation conditions over Europe and customer's warning purposes is introduced by the following equation:

AI(foF2) (%)= 100*(foF2 - foF2 $^{\text{30-day running median}}$)/foF2 $^{\text{30-day running median}}$

Criteria for ionospheric activity:

- **AI(foF2) within ±25% low ionospheric activity**
- **AI(foF2) within ±25% to ±50% disturbed ionospheric conditions**
- **AI(foF2) beyond ±50% extremely disturbed ionospheric conditions**

Bremer, J. Lj.R. Cander, J. Mielich and R. Stamper, DIAS Report on derivation and testing of ionospheric activity indices in the European region, 2005
Bremer, J. Lj.R. Cander, J. Mielich and R. Stamper, Derivation and test of ionospheric activity indices from real-time ionosonde observations in the European region, submitted to JASTP, 2006.

Forecasting the absolute foF2 value using AutoRegressive models (Koutroumbas and Belehaki, 2005)

Estimation of the value x(n+s) (s>0) based on a set of M past values:

x(n), x(n-1),…x(n-M) → x(n+s)

Assumption: x(n+s) depends linearly on x(n), x(n-1), …, x(n-M)

The estimation of x(n+s), $\hat{x}(n+s)$ is given by

$$\hat{x}(n+s) = w_0\, x(n) + w_1\, x(n-1) + \cdots + w_M\, x(n-M)$$

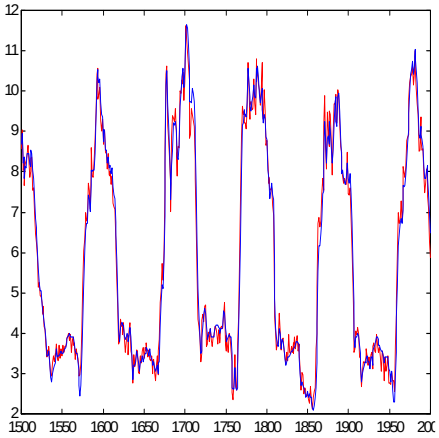
where

- M is the *order* of the model
- $\boldsymbol{w}=[w_0, w_1, \ldots, w_M]^T$ is the *parameter vector* of the model

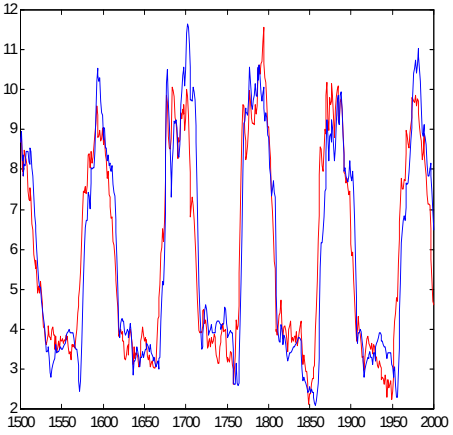
An AR-model is completely determined by

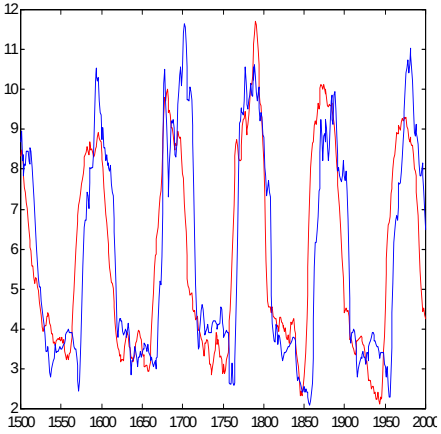
- its order M
- its parameter vector $\boldsymbol{w}$

15 minute prediction

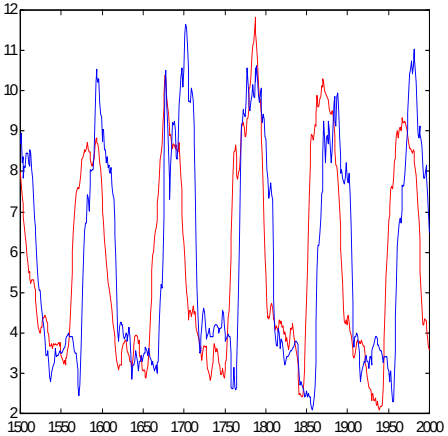


1 hour prediction

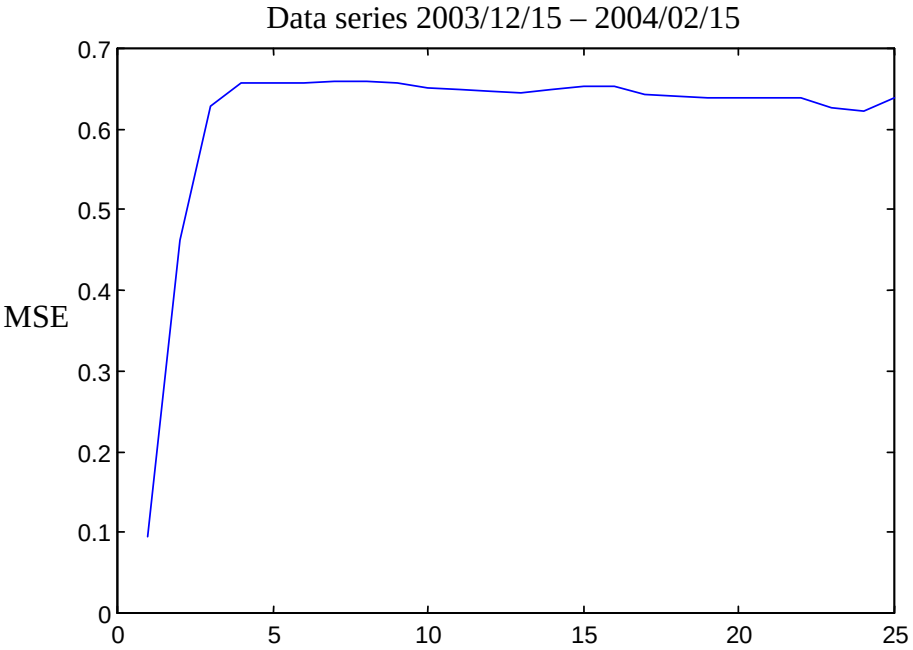




2 hour prediction



3 hour prediction



Results from test of the model with 15 min data from Athens Digisonde for the period 2003/12/15 – 2004/02/15 [Actual (blue) and predicted (red) values]

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1. Defence industry – short-term
2. Civil aviation – short-term
3. Defence – medium term plan
4. Upper atmosphere research
5. Civil aviation – medium term plan
6. Civil HF broadcast

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http://dias.space.noa.gr:8080/Dias/loginMonitor.jsp (from your PDA)

or following the links in DIAS web site
http://www.iono.noa.gr/DIAS

The access is password protected and is provided for free to all the members of the DIAS network.

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DIAS home page http://www.iono.noa.gr/DIAS